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SESAR Solution PJ.02-W2-21.4 SPR-INTEROP/OSED for V3 - Part I

Deliverable ID:	**D6.4.001**
Dissemination Level:	**PU**
Project Acronym:	**AART**
Grant:	**874477**
Call:	**H2020-IBA-SESAR-2019-1**
Topic:	**Airport Airside and Runway Throughput**
Consortium Coordinator:	**Eurocontrol**
Edition Date:	**27 January 2023**
Edition:	**00.03.03**
Template Edition:	**02.00.06**

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Document History

Edition	Date	Status	Beneficiary	Justification
00.03.00	01/12/2021	Draft	Indra	Based on D6.2.001 Standalone for Sol21.4
00.03.01	18/05/2022	Draft	Indra	Update after executing validation exercise
00.03.02	30/09/2022	Final Draft	Indra	Updated after final review

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00.03.03	27/01/2023	For re-submission	Indra Navia	After SJU comments of 22 Dec 22 and Maturity Concerns

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AART

PJ.02 AIRPORT AIRSIDE AND RUNWAY THROUGHPUT

This SPR-INTEROP/OSED is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874477 under European Union's Horizon 2020 research and innovation programme.

Abstract

The SPR-INTEROP/OSED is composed of different parts. Part I, this document, provides the Safety and Performance Requirements (SPR) and Interoperability Requirements (INTEROP), related to the SESAR Solutions PJ.02-W2-21.4; Full Guidance Assistance to mobiles using 'Follow the Greens' procedures based on Airfield Ground Lighting (aprons/taxiways/runways), that have been validated during validation activities at a V3 level. They are presented in the context of the Operational Service and Environment Definition (OSED), which describes the environment and assumptions that are applicable to the SPR and INTEROP requirements.

Table of Contents

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List of Tables

List of Figures

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1 Executive Summary

SESAR SolutionPJ.02-W2-21.4 is titled Full Guidance Assistance to mobiles using 'Follow the Greens' procedures based on Airfield Ground Lighting (aprons/taxiways/runways). This solution intends to automate the prioritization of mobiles along their cleared route on the whole movement area. The Guidance Service considers other traffic to guide the mobile as it progresses along its assigned route and at the holding points. It allocates priorities between mobiles based on local operating rules (e.g. runway exit versus parallel taxiways, aircraft versus vehicle, aircraft converging or crossing at intersections and taxiways passing close to push back routes or other taxiways where insufficient wingtip separation exists) as well as known constraints from the surface management system. Automatic Guidance will be provided using “Follow the Green” concept on the Airfield Ground Lighting infrastructure.

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2 Introduction

2.1 Purpose of the document

This document provides the requirements specification, covering operational, safety, performance and interoperability requirements related to SESAR Solution PJ.02-W2-21.4

The SESAR Solution Development Life Cycle aims to structure and perform the work at project level and progressively increase SESAR Solution maturity, with the final objective of delivering a SESAR Solution data-pack for industrialisation and deployment. The SPR-INTEROP/OSED represents one of the key parts of this SESAR Solution data-pack.

2.2 Scope

This is the SPR-INTEROP/OSED for Solution PJ.02-W2-21.4 for V3 phase in its final version following the validation activities performed and reported in the D6.4.004 PJ.02-W2-21.4 VALR [25].

These requirements will cover safety, performance, operational aspects as well as the interoperability aspects related to the specific technology to support the SESAR Solutions PJ.02-W2-21.4

2.3 Intended readership

The intended audience of this initial OSED for the Solution PJ.02-W2-21.4 are:

- the SESAR Projects developing Solutions related to High Performing Airport Operations, and in particular the solutions PJ.02-W2-21.1 "*Enhanced airport safety support tools for controllers at A-SMGCS Airports*" and PJ.02-W2-21.5 "*Enhanced Safety in LVP through use of Dynamic Virtual Block Control*".
- SESAR 2020 Wave 2 Transversal Projects:
    - PJ19 CI (Content Integration) responsible for managing the content integration process to ensure the needed coherency (in terms of operational concept, architecture) between the different SESAR 2020 projects.
    - PJ20 AMPLE (Master Plan Maintenance) responsible for ATM Master Plan maintenance

2.4 Background

Solution PJ.02-W2-21.4. This Solution enhances the Release 5 SESAR1 **Solution #47** "Guidance assistance through airfield ground lighting" [27]. The SESAR1 Solution #47 is known as OI Step AO-0222-A, and the Solution PJ.02-W2-21.4 is known as OI Step AO-0222-B

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This new solution intends to automate the prioritisation of mobiles along their cleared route on the whole movement area. The Guidance Service takes into account other traffic for spacing to guide the mobile as it progresses along its assigned route and at the holding points.

2.5 Structure of the document

The SPR-INTEROP/OSED deliverable is composed of different parts.

Part I - this document - provides the Safety and Performance Requirements (SPR) and Interoperability Requirements (INTEROP), related to the SESAR Solutions PJ.02-W2-21.4 that aim for validation at a V3 level. They are presented in the context of the Operational Service and Environment Definition (OSED), which describes the environment and assumptions that are applicable to the SPR and INTEROP requirements.

The document is completed by appendices including:

- The Benefit and cost Mechanisms, showing how the SESAR Solution elements contribute (positively or negatively) to the delivery of performance benefits and the costs.

Parts II to V provide the series of assessments performed at SESAR Solution level that justify the SPR and INTEROP requirements:

- Part II: The Safety Assessment Report describes the results of the safety assessment work for the SESAR Solution.
- Part IV: The Human Performance Assessment Report describes the results of the Human Performance assessment work for the SESAR Solution.
- Part V: The Performance Assessment Report (PAR) that consolidates the performance results obtained in different validation activities at SESAR Solution level.

2.6 Glossary of terms

Term	Definition	Source of the definition
Advanced Routing	In addition to the "basic routing" investigated during SESAR 1, the advanced routing function of SESAR 2020 is expected to suggest alternative routes to the cleared routes of one or more of the mobiles, to remove the potential deadlock / conflicting situations or to dynamically adapt routing to known operational constraints or traffic behaviour situation.	SESAR 2020 PJ03a-01 and PJ.02-W2-21.6
Advanced Surface Movement Guidance	A system providing as a minimum Surveillance and can include Airport Safety Support, Routing and	EUROCONTROL A-SMGCS Specification

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and Control System (A-SMGCS)	Guidance to aircraft and vehicles in order to maintain the airport throughput under all local weather conditions whilst maintaining the required level of safety.	No171 V2.0 Dated 22 April 2020
Alternative route-choice function	Means for the controller to choose a route from a provided list of alternative routes, e.g. via a menu	PJ03a-01 definition
A-SMGCS Guidance service	The Guidance Service provides individual guidance information using visual aids to any mobile which has a cleared taxi route. It comprises the following three functions: • Automated switching of Taxiway Centreline Lights (TCL). • Automated switching of stop bars. • Automated activation of Advanced-Visual Guidance Docking Systems (A-VDGS).	EUROCONTROL A-SMGCS Specification No171 V2.0 Dated 22 April 2020
A-SMGCS Routing service	The Routing Service generates individual routes for mobiles based on known aerodrome parameters and constraints or following an interaction by the Controller and is a key enabler for the Guidance Service and some elements of the Airport Safety Support Service.	EUROCONTROL A-SMGCS Specification No171 V2.0 Dated 22 April 2020
Electronic Clearance Input (ECI)	A generic term used to describe the means for a Controller to input Clearances or instructions.	EUROCONTROL A-SMGCS Specification No171 V2.0 Dated 22 April 2020
Intermediate Holding Position	A designated position intended for traffic control at which taxiing aircraft and vehicles shall stop and hold until further cleared to proceed, when so instructed by the aerodrome control tower	ICAO Annex 14
Routing	The planning and assignment of a route to individual aircraft and vehicles to provide safe, expeditious and efficient movement from its current position to its intended position.	EUROCONTROL A-SMGCS Specification No171 V2.0 Dated 22 April 2020
Visibility Condition 3 (VIS 3)	Visibility enough for the pilot to taxi but insufficient for the pilot to avoid collision with other traffic on taxiways and at intersections by visual reference, and insufficient for personnel of control units to exercise control over all traffic based on visual surveillance. For taxiing, this is normally taken as visibilities equivalent to an RVR of less than 400 m but more than 75.	ICAO Doc 9830 (Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual).

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Low Visibility Operations (LVOs)	Approach or take-off operations on a runway with any RVR less than 550 m or taxiing at an aerodrome at which any RVR is less than 550 m.	Regulation (EU) 2017/373, Air Traffic Management/Air Navigation Services
Manoeuvring area	Part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons.	Regulation (EU) 2017/373, Air Traffic Management/Air Navigation Services
Movement area	Part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron.	Regulation (EU) 2017/373, Air Traffic Management/Air Navigation Services

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
AART	Airport Airside and Runway Throughput
A-CDM	Advanced Collaborative Decision Making
AGL	Airfield Ground Lighting
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
AOC	Airport Operation Centre
AoR	Area of Responsibility
APTR	Alternative Parallel Taxiway Routing
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATIS	Automatic terminal information service
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit
BIM	Benefit Impact Mechanism
CBA	Cost Benefit Analysis
CMAC	Conformance Monitoring Alerts for Controllers
CNS	Communication Navigation and Surveillance

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CONOPS	Concept of Operations
CPDLC	Controller Pilot Data Link Communication
CWP	Controller Working Position
DMAN	Departure Manager
EATMA	European ATM Architecture
EIBT	Estimated In-Block Time
ECI	Electronic Clearance Input
EOBT	Estimated Off Block Time
FDPS	Flight Data Processing System
FtG	Follow the Greens
GNSS	Global Navigation Satellite System
HLOR	High Level Operational Requirement
HMI	Human Machine Interface
HP	Human Performance
HPAR	Human Performance Assessment Report
ICAO	International Civil Aviation Organization
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specifications
KPA	Key Performance Area
LVP	Low Visibility Procedures
NOTAM	Notice To Airmen
OI	Operational Improvement
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PCIL	Project Content Integration Leader
PCIT	Project Content Integration Team
R&D	Research & Development
R/T	Radio Telephony
RWY	Runway
SE-DMF	System Engineering Data Management Framework)
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking
SPR	Safety and Performance Requirements

TCL	Taxiway Centreline Lights
TLDT	Target Landing Time
TS	Technical Specification
TSAT	Target Start Up Approval Time
TTOT	Target Take-Off Time
TWY	Taxiway
UC	Use Case
VALP	Validation Plan
VALR	Validation Report
VHF	Very High Frequency

Table 2: List of acronyms

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3 Operational Service and Environment Definition

3.1 SESAR Solution PJ.02-W2-21.4: a summary

This solution intends to automate the prioritisation of mobiles along their cleared route on the whole movement area. The Guidance Service considers other traffic for spacing to guide the mobile as it progresses along its assigned route and at the holding points. It allocates priorities between mobiles based on local operating rules (e.g. runway exit versus parallel taxiways, aircraft versus vehicle, aircraft converging or crossing at intersections and taxiways passing close to push back routes or other taxiways where insufficient wingtip separation exists), as well as known constraints from the surface management system. Automatic Guidance will be provided using "Follow the Greens" concept on the Airfield Ground Lighting infrastructure.

Benefits are expected in increased safety performance in all weather conditions, improved predictability through guidance and reduced workload and stress for ATCOs, pilots and vehicle drivers.

SESAR Solution ID	SESAR Solution Title	OI Steps ID	OI Steps Title	Enabler ID	Enabler Title	OI Step/Enabler Coverage
PJ.02-W2-21.4	Full Guidance Assistance to mobiles using 'Follow the Greens' procedures based on Airfield Ground Lighting (aprons/taxiways/runways)	AO-0222-B	Full Guidance Assistance to mobiles using 'Follow the Greens' procedures based on Airfield Ground Lighting (aprons/taxiways/runways)	**AERODROME-ATC-07c**	A-SMGCS incorporating the function that provides No FtG CMAC Alert for Controllers	Optional / Developed (Full)
				AERODROME-ATC-61b	Advanced surface guidance management services to process the automatic triggering of airport ground signs and lighting according to	Required / Developed (Full)

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					the route issued by ATC	

Table 3: SESAR Solution PJ.02-W2-21.4 Scope and related OI steps/enablers

High Level Concept of Operations Requirement ID	High Level Concept of Operations Requirement	Reference to relevant Concept of Operations Sections e.g. Operational Scenario applicable to the SESAR Solution
S21.4-HLOR-01	Full Guidance Assistance to mobiles using 'Follow the Greens' procedures based on Airfield Ground Lighting (aprons/taxiways/runways) shall: • enhance situational awareness for vehicle drivers and pilots • reduce controller workload to obtain: • Increased Safety • Increased Predictability - by: • optimising routing and planning • providing enhanced guidance assistance for aircraft and vehicles to handle airport operations • considering potential conflicting situations when planning taxi routes	PJ19 W2 D2.0.002 High Level Operational Requirements-for W2 solutions, section 3.12.

Table 4: Link to Concept of Operations

3.1.1 Deviations with respect to the SESAR Solution(s) definition

AERODROME-ATC-07b (A-SMGCS incorporating the function that provides an advanced set of Conformance Monitoring Alerts for Controllers (CMAC) on the movement area) was at a first stage linked to AO-0222-B as 'Used'. This Enabler was shared between PJ.02-W2 Solution 21.1 and 21.4, but at a later stage it was decided that a new Enabler should be created as an extension of AERODOME-ATC-07c in order to focus on the 21.4 related aspects.

Therefore, AERODROME-ATC-07b was updated (CR 05578) by removing the reference to the CMAC "No FtG" (Not Follow-the-Greens) via CR 05578. A new Enabler, AERODROME-AT-07c (A-SMGCS incorporating the function that provides No FtG CMAC Alert for Controllers) was created via CR 06690 as an extension of AERODROME-ATC-07b.

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Afterwards, AO-0222-B was updated by removing the link to AERODROME-ATC-07b and adding AERODROME-ATC-07c as an Optional/Developed Enabler via CR 06691 (actually, AERODROME-ATC-07c was firstly set as Required by mistake in CR 06691, which was corrected by CR 07002, setting it as Optional/Developed).

3.2 Detailed Operational Environment

3.2.1 Operational Characteristics

Individual guidance via AGL may be used on a 24/7 basis in all weather conditions and on the entire movement area. Since the AGL technology is still quite expensive and the change management process accompanying the technical investments is complicated, it can be assumed that individual guidance via AGL could be implemented predominantly on Large and Very Large airports with complex TWY and RWY layouts.

In principle, wherever individual guidance via AGL will be implemented, the standard operational procedures for taxi-in and taxi-out could be based mainly on controlled lighting systems. Therefore, the integrated guidance network needs to be constructed with sufficient technical and procedural redundancy that guarantees high availability and reliability.

In order to avoid operational limitations due to the use of AGL, the selection process of the end devices, e.g. the TCLs, shall always take the climatologic environment and typical lighting conditions of the specific aerodrome into account. It can be assumed that accumulating AGL guidance service degradations will not be acceptable in terms of business case calculation and future resource planning.

The aerodrome will have Low Visibility Procedures (LVP) defined. LVP will be in force when required.

Taking into account forecasts from MET, ATC will co-ordinate with ATFM to manage the traffic (PANS-ATM, 3.2.5.2) in order to achieve optimum capacity for the aerodrome in the prevailing and expected conditions. The responsible ATS unit, in co-operation with the FMP and the unit providing ATFM services, will determine if ATFM measures are required to the reduce the capacity due to low visibility conditions and operation of LVP.

3.2.2 Roles and Responsibilities

3.2.2.1 Tower Controller (Tower Ground Controller, Tower Runway Controller)

The Tower Ground (ATS callsign “Ground”) and Tower Runway Controllers Ground (ATS callsign “Tower”) are responsible issuing ATC clearances and instructions and for monitoring that all movements on the manoeuvring area comply with the clearances issued. “Tower Ground Controller” and “Tower Runway Controller” are terms used in this project, but not widely used in ATM. ICAO Doc 4444 use the term “Aerodrome Controller” for the Air Traffic Controller of an Aerodrome Control Tower ATS unit (performing aerodrome control services), and is commonly also termed Tower Controller. “Tower Ground Controller” and “Tower Runway Controller” will be used in Use Cases for detailed understanding, but only “Tower Controller” will be used in requirements

In case an aircraft deviates from the route indicated by the AGL, the Tower Controller has to inform the Flight Crew immediately by R/T communication as an additional safety net accompanying the

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reaction of the guidance network. Related information may also be provided to the other mobiles involved, if applicable.

Depending on the automation of prioritisations at crossing or converging taxiway, the Tower Controller will have to enter, accept, or monitor guidance instructions with the ultimate possibility to intervene whenever needed.

In case of AGL service degradation, the Tower Controller is responsible for taking appropriate action.

3.2.2.2 Flight Crew

Flight crews are responsible to follow the cleared taxi route indicated by the AGL and the A-SMGCS Guidance service will provide reliable and intuitive information to the Flight Crew to support their navigation accordingly.

3.2.2.3 Vehicle Driver

The vehicle driver is responsible to follow the guidance information provided via AGL. They are also responsible for indicating any inability to act according to received AGL instructions.

Airport operations service vehicles may be guided via AGL when intentionally and unavoidably (for their specific task) operating on the taxiway centre line.

Fire service vehicles may also be guided via AGL. Individual guidance via AGL may help the fire service to identify the shortest way to the incident area. The use of AGL for this purpose is subject to local procedures.

3.2.3 CNS/ATS description:

ATS is provided in an environment with Advanced-Surface Movement Guidance and Control System (A-SMGCS), with Surveillance service, Airport Safety Support Service, Routing Service, and Guidance Service [23].

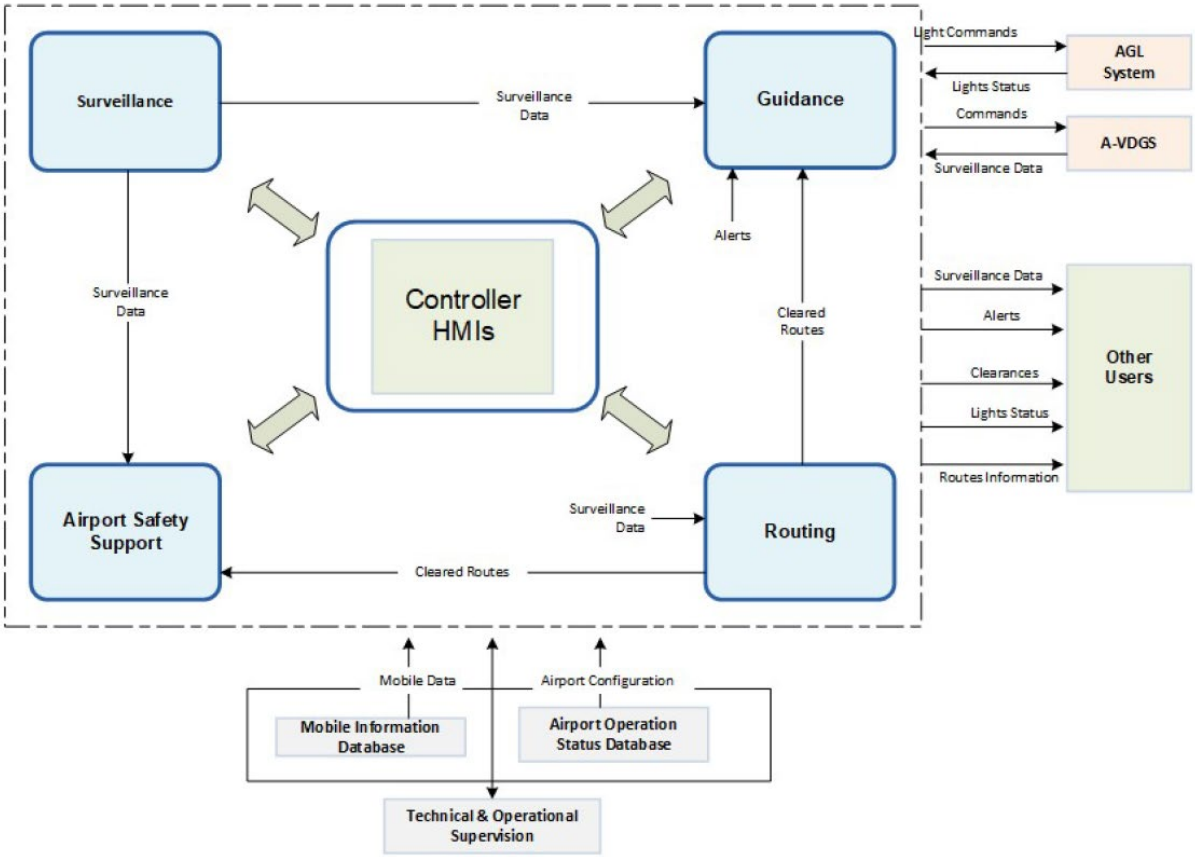

Figure 1 Example of an A-SMGCS Architecture [23]

The automated switching of the AGL is a function of the A-SMGCS Guidance Service which works in conjunction with the A-SMGCS Routing service. By knowing the cleared taxi route, the Guidance service illuminates the TCL a specified distance ahead of the mobile in question, switching them on and off automatically (including stop bars where applicable). The automated switching of the AGL automatically supports the provision of safe spacing on the aerodrome surface, including between converging mobiles, and in all weather conditions. The TCL are switched on and off according to the position of the mobile, therefore the quality of surveillance data is crucial for the Guidance Service to operate efficiently. Single lamp control or segment control (several lamps at the same time) are different means to switch the TCL in front of the mobiles.

The Controller HMI is also a support tool which needs to provide:

- Status of AGL: lights on/off
- Means to prioritise one mobile over another
- TCL and Stop Bars layout

The Guidance Service collects the information (current mobile positions, mobile routes, controller HMI input) to calculate the position and length of the guidance indication. This is translated into control commands to the Airfield Ground Lighting Service, which is in charge of switching the lighting components (TCLs, Stop Bars).

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3.2.4 Applicable standards and regulations

- EUROCONTROL, SPEC-171, Specification for A-SMGCS Services, Edition 2.0, 2020
- EUROCAE ED-87E, MASPS for A-SMGCS, April 2022 (version E includes A-SMGCS Guidance service).
- ICAO Doc 4444 Procedures for Air Navigation Services -Air Traffic Management 16th Edition, 2016.
- EASA Standardised European Rules of the Air (SERA) (EU Regulation 923/2012).
- ICAO Annex 14, Volume I, Edition 7, 2016.
- EASA Aerodrome Regulation (COMMISSION REGULATION (EU) No 139/2014.
- ICAO EUR Doc 013 European guidance material on all weather operations at aerodromes, Fifth Edition.

As a result of the research activities conducted within PJ.02-W2-21.4, it has been concluded that the Guidance Assistance through Airfield Ground Lighting may require updating ICAO standards for phraseology, which is mainly defined in ICAO Doc 4444 (PANS-ATM). Doc 4444 12.3.4.7 specifies phraseology for Taxi procedures and it is recommended to add new standard phraseology, where the following is proposed: “TAXI TO HOLDING POINT [number] [RUNWAY (number)] (or STAND [number]) FOLLOW THE GREENS”, associated to a “Condition” of “…where surface movement guidance by airfield ground lighting exist”.

Also, EASA SERA (Standardised European Rules of the Air) (EU regulation 923/2012), specifies taxi phraseology in Appendix 1 to AMC1 SERA.14001 General with ATC PHRASEOLOGIES (1.4.7). Also here it is proposed to add new standard phraseology for taxiing via “Follow the Greens”, in the same way as proposed above for ICAO Doc 4444: “TAXI TO HOLDING POINT [number] [RUNWAY (number)] (or STAND [number]) FOLLOW THE GREENS” associated to a “Circumstance” of “…where surface movement guidance by airfield ground lighting exist”.

These Standardisation needs have been documented in EATMA via the proper Change Requests, i.e. CR 06674 for updating ICAO Doc 4444 and CR 06675 for updating SERA AMC1.14001.

3.3 Detailed Operating Method

3.3.1 Previous Operating Method

Guidance service obtains the cleared route from the taxi clearance input by the Controller and illuminates the TCL to a specified distance ahead of the mobile in question, switching them on and off automatically.

Note: When referring to TCL this includes apron taxilane lights and lead in and lead out lights on a stand.

In SESAR 1, different validations were performed and indicated that the switching of TCL and stop bars could be automated by taking into account the clearances entered by the controllers, the route generated by the Routing service and the position of the mobile provided by the Surveillance Service.

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SESAR SOLUTIONS CATALOGUE 2019 Third edition #47/ Release 5 describe the following: [27]

"Airfield ground lighting offers a unique opportunity to guide aircraft and vehicles around the airport. By linking the lighting infrastructure with the taxi route management system, the airport can provide an unambiguous route for the flight crew and vehicle driver to follow.

The solution requires advanced technology within the lights themselves, and in the ramp control tower. The airfield lighting control system needs to turn on the lights ahead of an aircraft, and off immediately behind. To achieve this, taxiway centre line lights are automatically and progressively switched on in segments (or individually) as the aircraft (or the vehicle) moves along its assigned route. Pilots and vehicle drivers receive a single instruction to 'follow-the-greens' from air traffic control (ATC). If stop bars are implemented to protect no-go areas, they are also automatically commanded. The solution also relies on the surface movement guidance and control system to provide accurate aircraft position data.

The solution improves the safety of surface operations, especially during low-visibility conditions, through a reduction of runway incursions, taxi route deviations and holding position overruns. It increases situational awareness and improves the predictability of surface movement through a reduction in the variability of taxi times. The fewer speed changes also result in lower fuel consumption. As taxi speeds are globally increased, apron throughput is improved."

SESAR 1 OFA04.02.01 (Integrated Surface Management) Final OSED [29] also contributes to defining the previous operating method.

3.3.2 New SESAR Operating Method

3.3.2.1 Full guidance - overview

The Guidance service obtains the cleared route from the taxi clearance input by the Tower Controller and illuminates the TCL to a specified distance ahead of the mobile in question by switching them on and off automatically, and switching Stop Bars on and off automatically.

The guidance service is further improved by monitoring the progress of mobiles along their routes and taking into account potential conflicting situations with other mobiles to perform short-term trajectory predictions which support the automatic control of mobiles by TCL and stop bars in such a manner that conflicting situations are avoided. This may also be taken into account when regularly updating the remaining taxi times of aircraft.

The A-SMGCS Guidance service could look for the following situations, which typically require a change to the trajectory (i.e. on the mobile's path, its target time at a given point, the target time of a specific event, or a combination of these changes) of at least one aircraft:

- Simultaneous arrival at intersection: taxi routes with two mobiles converging toward the same intersection within the same timeframe. This situation would be solved by limiting the guidance of one of the mobiles as necessary. The choice of which mobile to affect depends on priority rules defined, that could be related to mobile type, mobile speed, procedures, A-CDM milestones, etc.

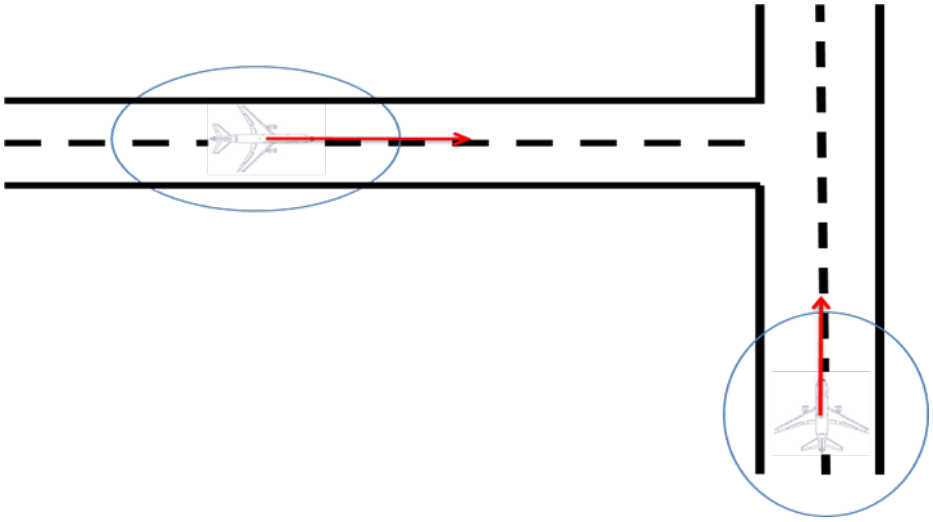

Figure 2: Intersection conflicting situation

- Head-on conflicting situation: taxi routes on a single taxiway or incompatible parallel taxiways with two mobiles moving in opposite directions without exit or entry points and using the same section of the taxiway in the same timeframe. It is commonly defined as “deadlock situation”.

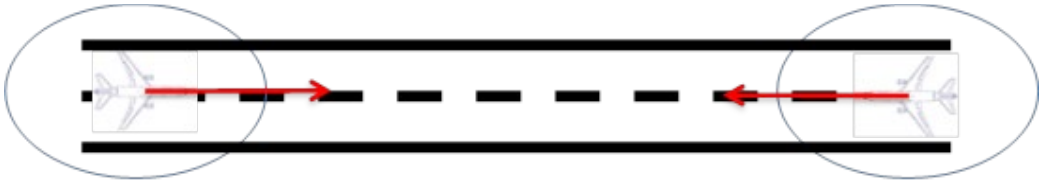

Figure 3: Head-on (deadlock) conflicting situation

- Catching up: routes with two mobiles taxiing in the same direction using the same section of the taxiway within the same timeframe and where the following aircraft speed is higher than the leading aircraft speed, resulting in an infringement of the separation bubble (applicable in visibility conditions where the flight crew of following aircraft may not have adequate visibility of the leading aircraft.

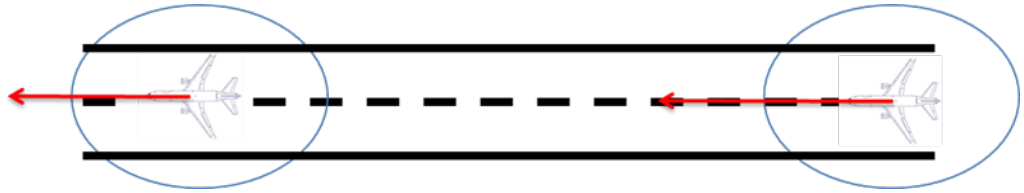

Figure 4: Catch-up on same taxiway portion

- Pushback on taxi lane conflicting situation: planned routes with two mobiles converging at the same intersection, in which one of them is planned to do pushback towards an intersection while blocking the advance of the other mobile

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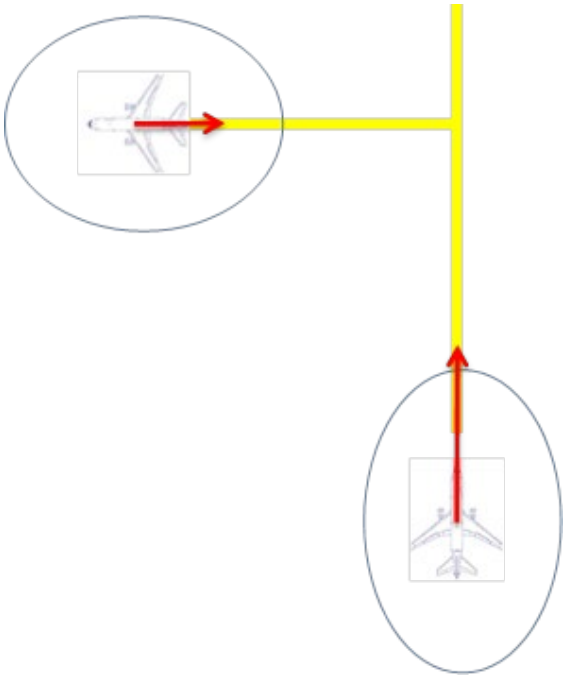

Figure 5: Pushback on taxi lane conflicting situation

3.3.2.2 Guidance through Airfield Ground Lighting

The Guidance Service through AGL provides the automated switching of the following visual aids in conjunction with Controller inputs, providing individual guidance information to any mobile which has a cleared taxi route:

- Taxiway Centreline Lights (TCL)
- Stop Bars.

Whilst other non-A-SMGCS guidance means are partly or fully depending on [aircraft] on-board installations, guidance via TCL is purely a ground-based service which works in conjunction with the A-SMGCS Surveillance and Routing services as well as the Electronic Controller Input (ECI) given by the Controller.

The Guidance service improves the navigation and flow of mobiles on the movement area and reduces the workload of the Controllers. The following sections describe the different means of A-SMGCS Guidance.

3.3.2.3 Automated Switching of the Taxiway Centreline Lights (TCL)

3.3.2.3.1 General

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Automated switching of TCL provides individual guidance information to any mobile which has a cleared route.

This function obtains the cleared route of a mobile from the clearance provided by the Controller and illuminates the TCL *(when referring to TCL this includes apron taxilane lights and lead in and lead out lights on a stand)* to a specified distance ahead of the mobile in question, switching them on and off automatically. This operation is already known as **Follow the Greens (FtG).**

Longitudinal spacing between mobiles is the responsibility of the Flight Crew or Vehicle Driver in non-LVP weather situations. Hence, the Automated TCL doesn't necessarily need to provide this spacing in good visibility.

The Guidance Service takes into account other traffic for spacing to guide the mobile as it progresses along its assigned route and allocates priority between mobiles based on local operating rules (e.g. Runway exit versus parallel taxiways, aircraft versus vehicle, aircraft converging or crossing at intersections and taxiways passing close to push back routes or other taxiways where insufficient wingtip separation exists).

Guidance information consists of the following elements:

- A single light or a group of lights in a short segment. All lights in the segment can only be activated or deactivated together.
- The activated lights are indicated by a locally configurable number of individual TCL or TCL segments. The length of the route indication and spacing from other mobiles may vary with external factors such as visibility conditions (e.g. non-LVP or LVP), kind of mobile, type of aircraft, topographical influences, aerodrome layout, desired velocity of the mobile, and others. The final decision on the length of the indication for a specific movement shall be taken according to local rules.

3.3.2.3.2 Presentation of conflicting taxi routes and priorities

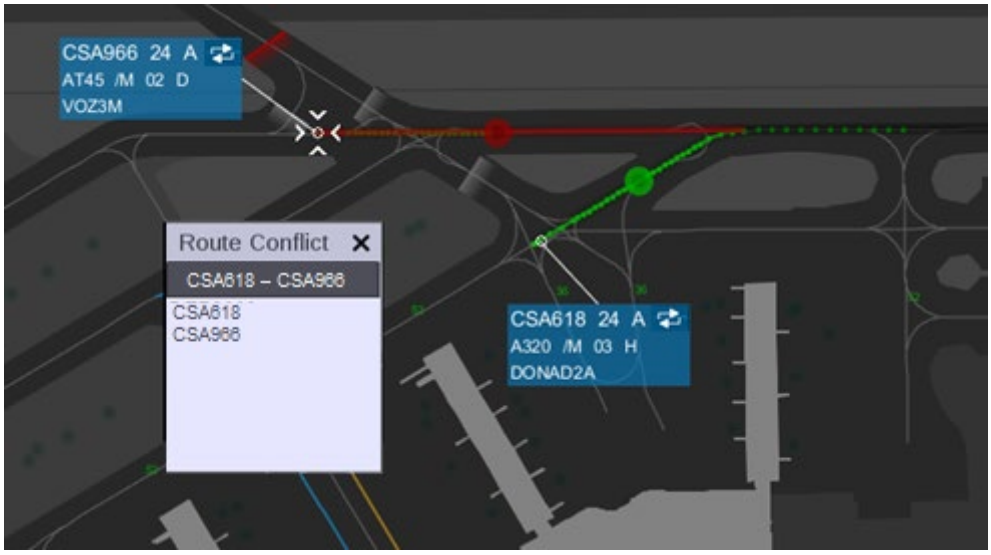

Figure 6: HMI representation of conflicting taxi routing

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For the Controllers to remain in the loop on the conflicts the solution detects, and the priorities automatically allocated, the HMI of the CWP need to be able to present this information to the controller in an efficient manner. Different HMI solutions can be envisaged, but the controller need to be informed that the solution has detected a conflicting situation, and the prioritisation allocated. The HMI also need to include input functionality to swap the priority. The detected conflict and prioritisation happens before the TCL are being restricted and observable by the flight crew. The controller may change the priority before the TCL are being restricted and observable by the flight crew.

3.3.2.3.3 Presentation of TCL to Controllers

For the Controllers to remain in the loop on guidance information being provided to Flight Crews and Vehicle Drivers, the current status of the TCL for each movement under his/her responsibility needs to be able to be displayed on the HMI of the CWP. The TCL information presented needs to be minimized to what is operationally relevant to avoid clutter on the screen.

The Controller needs to have indication of when a mobile's TCL are being restricted by the system when two or more mobiles are converging, where one of the mobiles is required to give way to the other(s). The Controller also requires an easy means of changing the priority of the TCL. Figure 6 shows the lit TCL in green in front of the aircraft and as an example; the restricted TCL of AFL2683 is highlighted by a red circle at the end of the lit TCL.

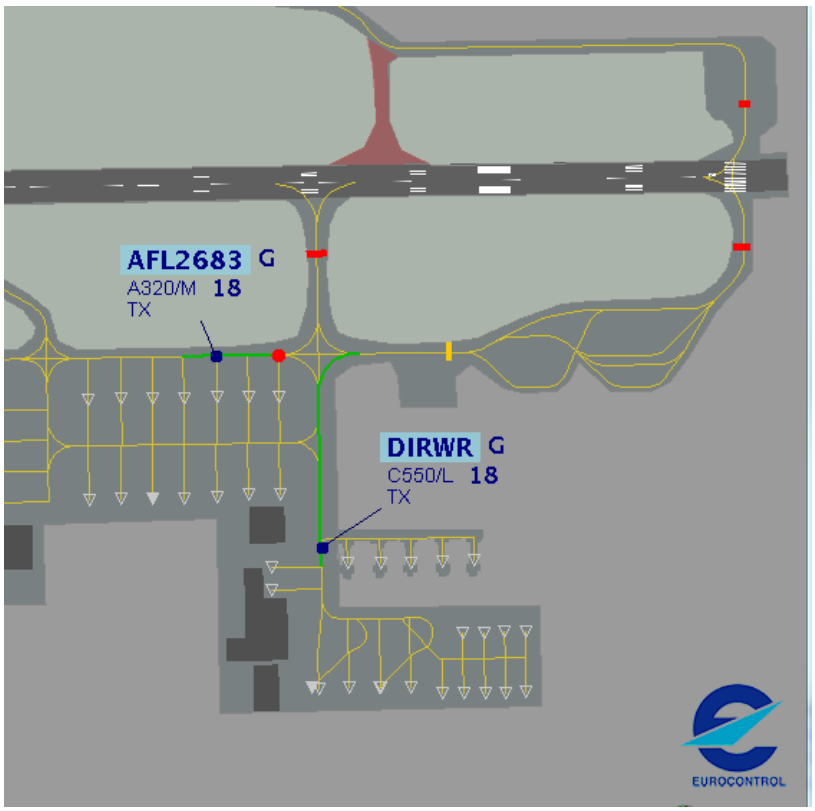

Figure 7: HMI representation of TCL

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3.3.2.4 Automatic Switching of Stop Bars

This function provides the capability to switch off stop bars following a clearance input by the Controller. They can either be placed at a RWY Holding Position (as already in use at many airports) or across a taxiway.

In the latter case, they can support spacing between crossing or converging ground trajectories by clearly indicating where to stop e.g. to sequence traffic at taxiway intersections. Additionally, stop bars can be used to maintain block spacing in LVP. The TCL segments must not be activated at least 90 metres after a lit stop bar.

3.3.2.5 Use Cases for Full Guidance assistance to mobiles using 'Follow the Greens' procedures based on AGL

The Operational Node View in the figure below summarises the information exchanges for PJ.02-W2-21.4 concepts for routing with AGL described in the following Use Cases:

Use Case 1	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)
Use case 2	[NOV-5] [GUID-02] Guidance of Vehicles – AGL environment
Use case 3	[NOV-5] [CMAC-03] No Taxi Alert / No FtG alert

Table 5. Use Cases and corresponding NOV-5 comprised by [NOV-2] Routing with AGL

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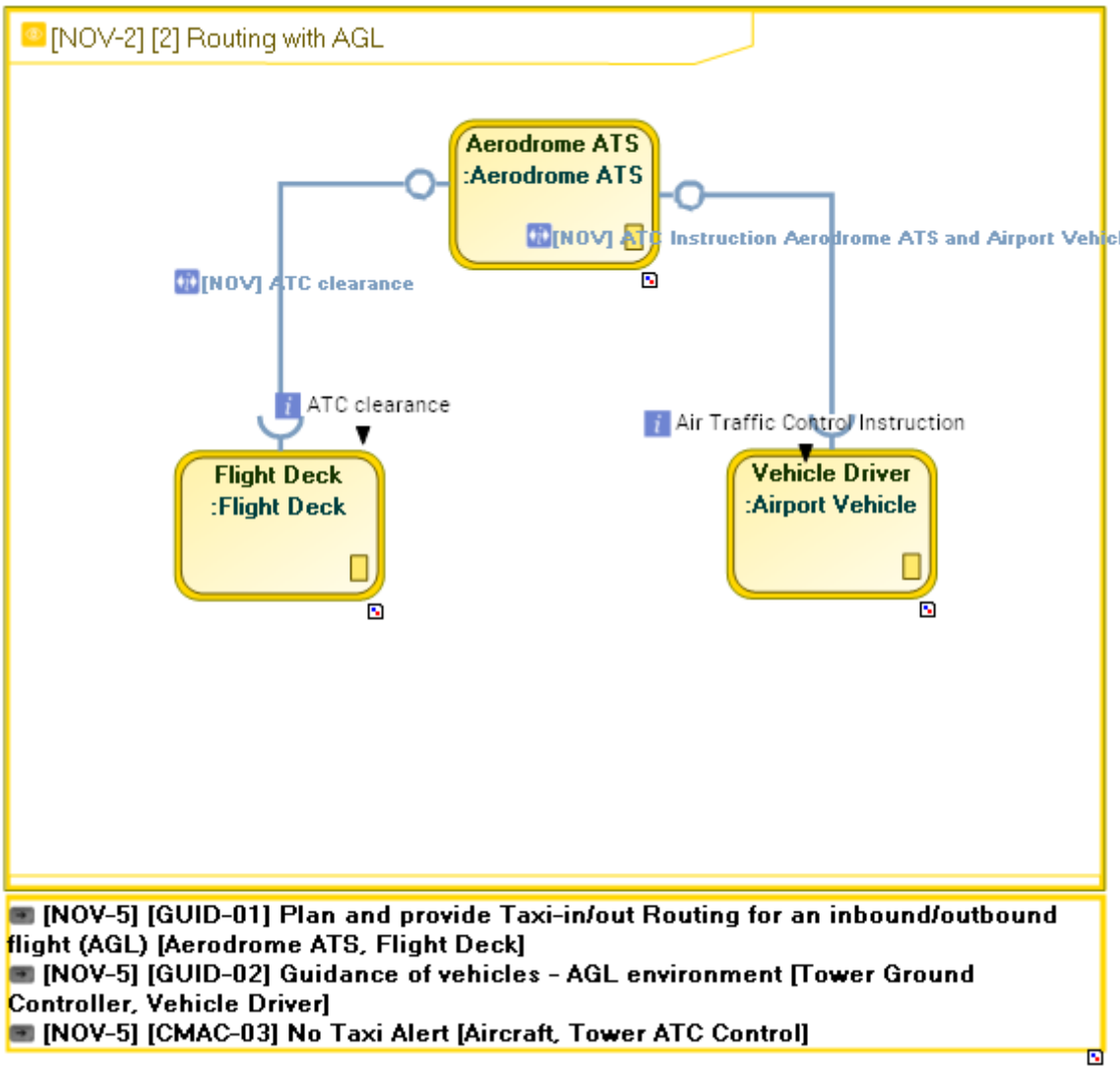

Figure 8. [NOV-2] Routing with AGL

3.3.2.5.1 Use Case 1: "Plan and Provide Taxi-In/Out Routing for an inbound/outbound flight" – AGL environment only (no datalink)

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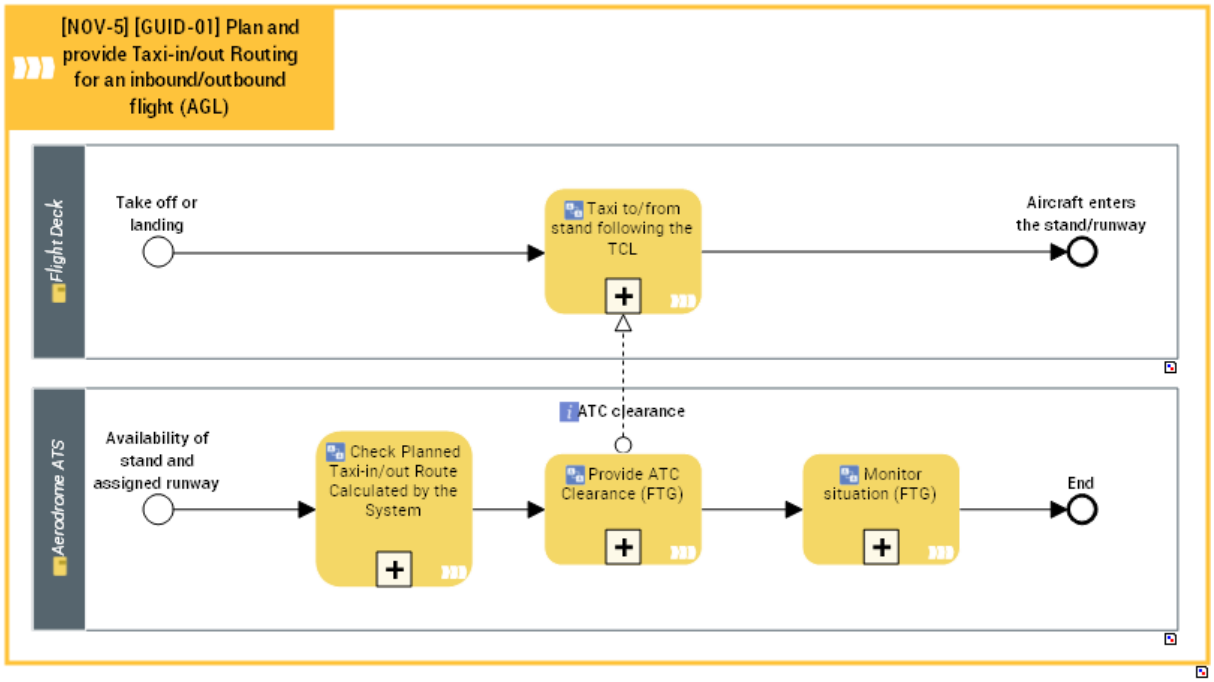

Figure 9. [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

This Use Case describes how the Full Guidance Assistance is provided along a planned taxi route for a flight. This Use Case also describes the guidance provided to a flight, how the cleared taxi route is presented to the Tower Controller, how the cleared taxi route will be transmitted to the Flight Crew. It also describes how the AGL are operated in conjunction with the cleared route.

Pre-Conditions

- The ATC system is equipped with A-SMGCS surveillance, Routing service and a means to input ATC clearances
- The airport is equipped with a full guidance function that automatically switches Taxiway Centre Line lights (TCLs) (“Follow the Greens”)
- The aircraft has landed and is about to start the taxi phase, or the aircraft is ready to start taxi from stand (or ready to push from stand)

Post-Conditions

- The taxi phase ends – the aircraft has reached its parking stand, or is lined up at the runway for take-off

Actors

- Tower Runway Controller
- Tower Ground Controller
- Flight Crew

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Nominal Flow - The taxi-in part of the use case

1. The A-SMGCS Routing service is informed about the assigned landing runway, stand and Target Landing Time (TLDT) for the flight.

2. The A-SMGCS Routing service calculates the planned taxi-in route, based on information available, such as taxiway rules, closed taxiways and standard taxi routes, as well as allocated stand and anticipated runway exit.

3. The planned taxi-in route is used to calculate an accurate taxi time. This taxi time is used to refine the Estimated In-Block Time (EIBT).

4. At a defined time and/or distance before the aircraft reaches the runway threshold, the AGL system is commanded to illuminate the TCLs for all possible runway exits for guidance purposes. The TCLs are lit to the point that is determined by the Aerodrome ATS to be the clearance limit of a landing clearance (for each runway exits)

5. The aircraft lands and vacates the runway.

6. The AGL system is commanded to switch off the TCLs for the not used runway exits, unless the next aircraft landing on the runway is already within the defined time and/or distance before the runway threshold

7. The Tower Runway Controller instructs the Flight Crew by R/T to contact the Tower Ground Controller. (When separate Ground control is in use)

8. The Flight Crew acknowledge and contact the Tower Ground Controller via R/T.

9. The Tower Ground Controller issues the taxi clearance “Follow the Greens to <clearance limit>” via R/T and updates the system with the taxi clearance by making an input to the HMI.

Note: It is assumed that the <clearance limit> will normally be either the assigned stand or the limit of the area of responsibility of the Tower Ground Controller issuing the “Follow the Greens” instruction.

10. The Flight Crew acknowledge the taxi instruction by R/T.

11. The A-SMGCS HMI displays the portion of the route that has been approved for taxiing as cleared route and the remaining part (if any) of the route as yet to be cleared (pending).

12. The AGL system is commanded to turn on individual lamps or segments of lamps of the taxiway centre lights (TCL) associated to the cleared taxi route, up to an appropriate distance in front of the aircraft.

13. The A-SMGCS HMI displays the individual lamps or segments of the AGL that are illuminated.

14. The Flight Crew commence to taxi the aircraft along the cleared taxi route. The solution automatically switches on new individual lamps or segments of lamps in front of the aircraft, according to the aircraft position and the route in order to keep a fixed length of lit TCL in front of the aircraft. The solution switches off lamps behind the aircraft.

15. The aircraft enters the stand.

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16. The use case part ends.

Alternative Flows during taxi in

At step 5, Flight crew misses the runway exit foreseen in the planned taxi-in route

1. The solution detects that the aircraft has missed the planned runway exit.
2. The A-SMGCS Routing service re-calculates a new planned taxi-in route taking into account the next suitable runway exit.
3. Estimated taxi time and EIBT are recalculated.
4. The flow continues at step 6.

At step 14 a revised planned taxi-in route is calculated by the A-SMGCS Routing service following a change to a known constraint (e.g. runway configuration/stand change, taxiway closure,…)

1. The A-SMGCS Routing service re-calculates the planned taxi-in route, based on the new information available in the ATC system.
2. Estimated taxi time and EIBT are re-calculated.
3. The flow continues at step 11.

Nominal Flow - The taxi-out part of the use case

1. The A-SMGCS Routing service is informed about the assigned departure runway, stand and TSAT for the flight are available.
2. The A-SMGCS Routing service calculates the planned taxi-out route, based on information available in the ATC system, such as taxiway rules, closed taxiways and standard taxi routes.
3. The calculated planned taxi-out route is used by the A-SMGCS system to calculate an estimated taxi time. This taxi time is used by the DMAN to refine the TSAT/TTOT.
4. The A-SMGCS system informs the Tower Clearance Delivery Controller that the planned taxi-out route is available.
5. The Flight Crew requests the Departure Clearance via R/T.
6. The Tower Clearance Delivery Controller issues the ATC Departure Clearance and updates the system, indicating that the Departure Clearance has been delivered.
7. The Tower Clearance Delivery Controller transfers the aircraft to the Tower Ground Controller (or to the Apron Manager, depending on the airport organisation).
8. The Flight Crew contacts the Tower Ground Control via R/T and requests push back.

Note: In addition, a specific time and push back direction may be added.

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9. The Tower Ground Controller approves the push back via R/T and makes an input to the HMI. The Tower Ground Controller may input the end of the pushback, pull out, or push-out procedure manually.

10. The Flight Crew acknowledges the pushback approval via R/T.

11. The Flight Crew instructs the ground handler (tug driver) accordingly (or at some airports the tug driver receives instructions directly from the Tower Ground Controller).

12. The A-SMGCS HMI displays the portion of route that has been cleared (push back) and the remaining part of the route as yet to be cleared (pending).

13. The push back is completed and the Flight Crew request start-up approval to the Tower Ground Controller by R/T.

14. The Tower Ground Controller approves the start-up via R/T and makes an input to the HMI. Note: In addition, a specific time may be added.

15. The Flight Crew acknowledges the start-up approval via R/T.

16. The Flight Crew commences to start up the engine/s.

17. The start-up is completed and the Flight Crew request taxi instructions by R/T.

18. The Tower Ground Controller verifies the planned taxi-out route and issues the taxi instruction “Follow the Greens to <clearance limit>” via R/T and makes an input to the HMI.

Note: It is assumed that the <clearance limit> will normally be either the holding point for the departure runway or the limit of the area of responsibility of the Tower Ground Controller issuing the “Follow the Greens” instruction.

19. The Flight Crew acknowledges the taxi instructions via R/T.

20. The A-SMGCS HMI displays the portion of the route that has been approved for taxiing as cleared route and the remaining part of the route as yet to be cleared (pending).

21. The AGL system is commanded to turn on individual lamps or segments of lamps of the taxiway centre lights (TCL) associated to the cleared taxi route, up to an appropriate distance in front of the aircraft.

22. The A-SMGCS HMI displays the individual lamps or the segments of the AGL that are illuminated.

23. The Flight Crew commences to taxi the aircraft along the cleared taxi route. The solution automatically switches on new individual lamps or segments of lights in front of the aircraft, according to the aircraft position and the route in order to keep a fixed length of lit TCL in front of the aircraft. The solution switches off lights behind the aircraft.

24. The Tower Ground Controller instructs the Flight Crew by R/T to contact the Tower Runway Controller.

25. The Flight Crew contact the Tower Runway Controller by R/T.

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26. On reaching the Holding Point the Tower Runway Controller issues line up clearance, or a take-off clearance, by R/T to the Flight Crew.

27. The Tower Runway Controller informs the system via an input to the HMI that line up or take-off clearance has been given.

28. The stop bar turns off and the TCL turns on showing the taxi route onto the runway.

29. The aircraft enters the runway and lines-up.

Alternative Flow during taxi out

When de-icing conditions prevail.

1. The A-SMGCS Routing service is informed about the assigned departure runway, stand, TSAT, requirement for de-icing (i.e. no de-icing, de-icing at stand, de-icing after push back or remote de-icing), allocated de-icing area (for remote de-icing) and expected de-icing time (when de-icing is required) for the flight are available.

2. The A-SMGCS Routing service calculates the planned taxi-out route (up to the Runway / Holding Point), based on information available in the ATC system, such as taxiway rules, closed taxiways, standard taxi routes and de-icing areas location if remote de-icing is required.

3. The calculated planned taxi-out route is used by the ATC system to calculate an estimated taxi time. The expected de-icing time is taken into account to calculate this taxi time. This taxi time is used by the DMAN to refine the TSAT/TTOT.

4. The flow continues at step 4.

A revised planned taxi-out route is calculated by the A-SMGCS Routing service following a change to a known constraint (e.g. runway configuration, taxiway closure,…).

1. The A-SMGCS Routing service re-calculates the planned taxi-out route, based on the new information available in the ATC system.

2. The ATC system recalculates the corresponding estimated taxi time, and if necessary, updates the TSAT/TTOT.

3. The flow returns to step 4.

Note: any update of the requirement for de-icing or of an allocated de-icing area is considered as a change to a known constraint.

The aircraft requires remote de-icing.

1. The start-up is completed and the Flight Crew request taxi instructions to the de-icing area by R/T.

2. The Tower Ground Controller verifies the planned taxi-out route and issues the taxi instruction “Follow the Greens to <clearance limit>” via R/T and makes an input to the HMI.

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Note: the message may not indicate a specific de-icing bay (NE4 for example) but a stop before the allocated de-icing area (NE in the above example) because it is assumed the de-icing bay allocated to the aircraft is not known at this stage.

3. The Flight Crew acknowledges the taxi instructions via R/T.
4. The A-SMGCS HMI displays the portion of the route that has been approved for taxiing as cleared route and the remaining part of the route as yet to be cleared (pending).
5. The solution turns on individual lamps or segments of lamps of the taxiway centre lights (TCL) associated to the cleared taxi route.
6. The A-SMGCS HMI displays the individual lamps or the segments of the AGL that are illuminated.
7. The Flight Crew commences to taxi the aircraft along the cleared taxi route. The solution automatically switches on segments of lights in front of the aircraft, according to the aircraft position and the route. The solution switches off lights behind the aircraft.
8. Once the Tower Ground Controller receives from the de-icing manager the de-icing bay allocated to the aircraft, the Tower Ground Controller updates the cleared trajectory via an input to the HMI.
9. The Tower Ground Controller instructs the Flight Crew to contact the de-icing agent via R/T.
10. The Flight Crew contacts the de-icing agent via R/T.
11. Once de-icing is complete, the Flight Crew contacts the Tower Ground Controller via R/T and informs that de-icing is complete.
12. After the de-icing checklist is completed, the Flight Crew request taxi instructions by R/T in order to vacate the de-icing bay and resume taxi.
13. The flow resumes at step 17.

Between step 23 and 24 – The Flight Crew requests a change of taxi-out route or Holding Point.

1. The Flight Crew contact the Tower Ground Controller via R/T, stating their request.
2. The Tower Ground Controller examines the request.
3. The Tower Ground Controller modifies, the taxi out route in the System.
4. The Tower Ground Controller approves the request by issuing a new “Follow the Greens <clearance limit> instruction via R/T.
5. The Flight Crew acknowledge it via R/T.
6. The Use Case returns to step 23.

Between step 23 and 24 The Flight Crew requests to return to the gate for technical reasons.

1. The Flight Crew contact the Tower Ground Controller via R/T, stating their request.
2. The Tower Ground Controller assesses the request and modifies, the taxi-out route in the System into a taxi-in route.
3. The Use Case returns to step 9 in the Use Case "Plan and Provide taxi-in routing for an inbound flight" – AGL environment (no datalink)

Alternative Flow during taxiing in general (both taxi in and taxi out)

The Tower Ground Controller decides to modify the taxi route

1. The Tower Ground Controller decide to change the route after FtG clearance have been given.
2. The Tower Ground Controller modifies the taxi route in the System via the HMI.
3. If the changed route is part of the TCLs already lit in front of the aircraft, the ATCO will notify the flight crew by R/T to alert the crew that the guidance will change.
4. The guidance will continue according to the modified route.

The taxiing involves crossing an active runway

1. When reaching the Stop Bar at the Holding Point of the runway, the Tower Ground Controller instructs the Flight Crew by R/T to contact the Tower Runway Controller.
2. The Flight Crew contact the Tower Runway Controller by R/T.
3. The Tower Runway Controller issues a clearance by R/T to Cross Runway to the Flight Crew.
4. The Tower Runway Controller informs the system via an input to the HMI that the Crossing clearance has been given.
5. The Flight Crew acknowledge the crossing clearance via R/T.
6. The stop bar turns off and the AGL turns on showing the taxi route onto and off the runway up until the area of responsibility of the next Tower Controller.
7. The Flight Crew crosses the runway.
8. The Tower Runway Controller instructs the Flight Crew by R/T to contact the Tower Ground Controller.
9. The Flight Crew contact the Tower Ground Controller.

The aircraft is on a conflicting route with another aircraft (or vehicle)

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1. The solution monitors constantly the positions and cleared routes for all aircraft and detects a conflict.
2. The aircraft is either given priority by the solution, or the aircraft in conflict (the other aircraft) is given priority by the solution as determined by priority rules.
3. The A-SMGCS HMI indicate the aircraft pair that is in conflict, where the conflict is predicted, and the prioritization. The Ground controller can also select to view the routes, assess the situation (the routes and prioritization)
4. If the aircraft is given priority the TCL will continue as normal to be lit as the aircraft moves, keeping the length of lit TCL as constant as possible.
5. If the other aircraft in conflict is given priority, the solution will determine how far the aircraft can continue to taxi (but will have to stop at, if it reaches) according to spacing rules. New TCL will continue to be lit only up to this point. The flight crew will observe that TCLs does not continue to be progressively lit, and the length of lit TCL in front of the aircraft will become shorter and shorter as the aircraft continue taxiing.
6. The flight crew of the aircraft that does not have priority (that have to give way) will assess the situation by observing the aircraft that have priority, and adjust the taxiing speed as needed, and stop if required and not overrun the last lit TCL.
7. The A-SMGCS HMI displays an indication (red dot or other clear indication) at the end of the line of TCL that are lit to indicate clearly to the Tower Ground Controller where the aircraft must stop if required (a temporarily taxi limit).
8. When the aircraft are no longer in a conflicting situation, the solution will automatically switch on TCLs again in front of the aircraft that had to give way and continue to guide the aircraft on the cleared route.
9. The A-SMGCS HMI removes the red dot (or similar indication) that indicated the temporarily taxi limit.

The Tower Controller change priority

1. When the A-SMGCS HMI indicate a conflict, and indicate the priority, the Controller decide to swap the priority
2. If the solution has already started to solve the conflict and discontinue to lit new TCL in front of the aircraft being restricted, the Controller will inform both flight crews that the priority will change (as one aircraft may suddenly get a reduced number of lit TCL in front, and may have to reduce speed more, and may have to stop with a shorter in pre-warning than normal)
3. The Controller execute the swap priority command in the A-SMGCS HMI
4. The conflicting situation will be solved with the modified priority.

Aircraft taxiing (queuing) behind another aircraft

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1. In normal visibility conditions, the length of TCL lit in front of the aircraft will be according to the parameters used, or if the distance between the aircraft is shorter than this distance, the TCL will be lit until the position of the aircraft in front. (there may also be a gap). The pilot will determine what is a safe distance to the aircraft in front.

2. If the cleared taxi routes of the aircraft following each other split up the guidance for the second aircraft will only be visible/fully activated once the first aircraft have passed the point where the routes split. This is because the first aircraft should only have visible the TCL it will follow. The second aircraft should be notified by the Controller in such situations.

Low Visibility Procedures in force

1. The Aerodrome ATS determines that the weather conditions and visibility is such that Low Visibility Procedures is required

2. The Tower Controller make “LVP active” input on the A-SMGCS HMI

3. The solution will use spacing parameters that are to be used for LVP. (greater spacing at intersections, and spacing when in line/queuing)

4. An aircraft following another will be kept at a safe distance from the one in front by always maintaining a distance of unlit TCL in between them.

Failure Flows

The A-SMGCS Routing service cannot calculate a planned taxi-out route for a specific flight/all flights.

1. The system informs the Tower Controller/Supervisor that no planned taxi-out route can be calculated for the flight/all flights.

2. The Tower Controller/Supervisor takes appropriate action to resolve the problem following local procedures.

3. The Use Case returns to step 6.

The AGL is in operation and the A-SMGCS Routing and Guidance services fail.

1. All TCL will be switched off as fall-back.

3.3.2.5.2 Use Case 2: “Guidance of Vehicles” – AGL environment (no data link)

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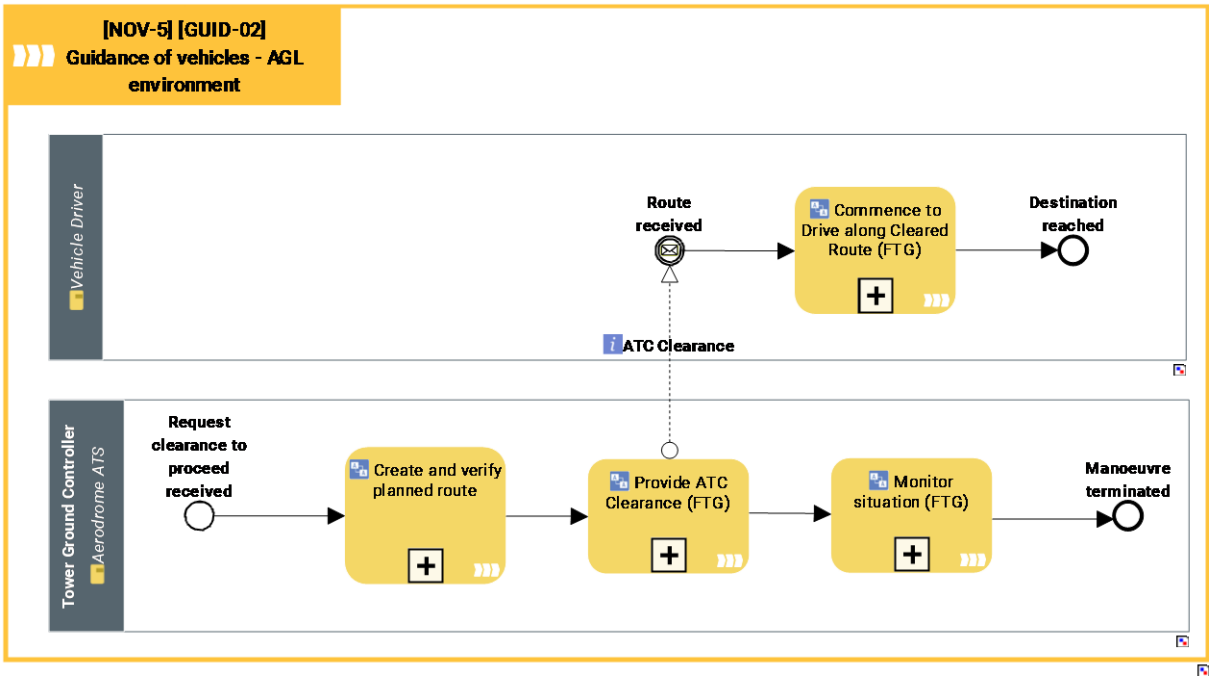

Figure 10 [NOV-5] [GUID-02] Plan and provide routing for an airport vehicle

General Conditions (Scope and Summary)

This Use Case describes the guidance provided for a vehicle on the manoeuvring area, how the cleared route is presented to the Controller, how the cleared route will be transmitted to the Vehicle Driver and how the driver will exploit the route information. It also describes how the AGL are operated in conjunction with the cleared route.

This Use Case takes place in the Medium to Short-Term Planning operational scenario, although vehicles are not strictly speaking concerned with the same phases as an aircraft.

The airport in this Use Case is equipped with an A-SMGCS, ECI and AGL.

The vehicle is equipped with R/T.

Pre-Conditions
The Use Case is applicable in all weather conditions.

Post-Conditions
The vehicle has reached his destination.

Actors

- Vehicle Driver
- Tower Ground Controller
- Tower Runway Controller (for alternative flow only)

Trigger

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Vehicle driver requests a clearance to proceed to his destination.

Nominal Flow

1. The Vehicle Driver contacts the Tower Ground Controller via R/T and states his/her intention to proceed to his/her destination.
2. The Tower Ground Controller creates, the planned route in the System via the HMI.
3. The Tower Ground Controller verifies the previously created route and issues the instruction "Follow the Greens to <clearance limit>" via R/T and makes an input to the HMI.

Note: It is assumed that the <clearance limit> will normally be either the destination at the airfield or the limit of the area of responsibility of the Tower Ground Controller issuing the "Follow the Greens" instruction.

4. The Vehicle Driver acknowledges the instruction via R/T.
5. The A-SMGCS HMI displays the portion of the route that has been approved as cleared route.
6. The solution command the AGL system to turn on individual lamps or segments of lamps of the taxiway centre lights (TCL) associated to the cleared route.
7. The Vehicle Driver commences to drive along the cleared route. The solution automatically switches on segments of lights in front of the vehicle, according to the vehicle position and the route. The solution switches off lights behind the vehicle.
8. The Vehicle Driver arrives at the destination and informs the Tower Ground Controller via R/T.
9. The Tower Ground Controller acknowledges the Vehicle Driver and informs the system via an input to the HMI that the manoeuvre is terminated.
10. The use case ends.

Alternative Flows

Between 7 and 8 – The Tower Ground Controller decides to modify the taxi route.

1. The Tower Ground Controller modifies the cleared route in the System via the HMI.
2. The flow returns to step 7

Between 7 and 8 – The Vehicle Driver requests a change of route.

1. The Vehicle Driver contacts the Tower Ground Controller via R/T, stating the request.
2. The Tower Ground Controller examines the request.
3. The Tower Ground Controller modifies the route in the System.
4. The flow returns to step 7 **¡Error! No se encuentra el origen de la referencia.**.

The vehicle route to the stand involves crossing an active runway

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1. When reaching the Stop Bar at the Holding Point of the active runway, the Tower Ground Controller instructs the Vehicle Driver via R/T to contact the Tower Runway Controller.
2. The Vehicle Driver contacts the Tower Runway Controller by R/T.
3. The Tower Runway Controller issues a clearance by R/T to Cross Runway 27L to the Vehicle Driver.
4. The Tower Runway Controller informs the system via an input to the HMI that the Crossing clearance has been given.
5. The Vehicle Driver acknowledges the crossing clearance via R/T.
6. The stop bar turns off and the AGL turns on showing the route onto and off the runway up until the area of responsibility of the next Tower Controller.
7. The Vehicle Driver crosses the runway.
8. The Tower Runway Controller instructs the Vehicle Driver by R/T to contact the Tower Ground Controller.
9. The Vehicle Driver contacts the Tower Ground Controller.
10. The flow resumes at step 7.

Failure Flows

Anywhere between 6 and 8 – The AGL is in operation and the A-SMGCS Routing and Guidance services fail.

1. All TCLs will be lit as fall-back.

3.3.2.5.3 Use Case 3: “No Taxi Alert” / “No FtG alert”

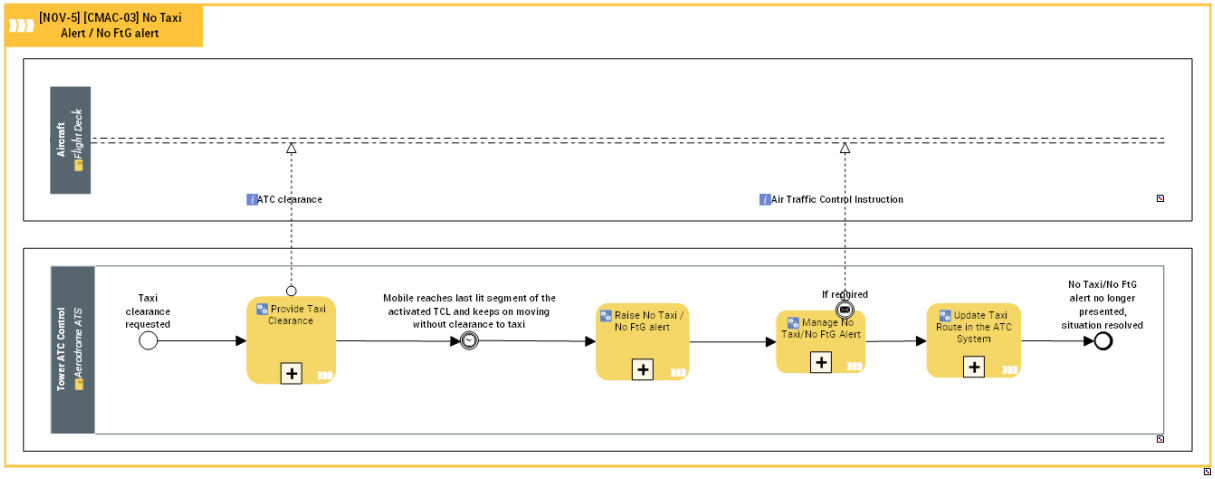

Figure 11 [NOV-5] [CMAC-03] No Taxi / No FtG Alert

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Scope/Description

This Use Case describes how the ATC system detects a **CMAC** No FtG alert when a mobile is being guided by the TCL (following the greens) and overruns the last lit segment of activated TCL and how it will be presented on the Tower Ground Controller's/Apron Manager's HMI.

Pre-Conditions

- The ATC system is equipped with A-SMGCS surveillance, Routing and a means to input ATC clearances
- The airport is equipped with a guidance function that automatically switches Taxiway Centre Line lights (TCLs) ("Follow the Greens") according to cleared trajectories validated by the Tower Ground Controller/Apron Manager and de-conflicted by the AGL guidance function

Post-Conditions

- The No Taxi/No FtG CMAC is resolved and the alert is no longer displayed on the Controller's HMI

Actors

- Tower Ground Controller/Apron Manager
- Flight Crew

Nominal Flow

1. The Pilot/Driver does not notice that the mobile has reached the last lit segment of the activated TCL he/she is following, and the mobile keeps on moving without clearance to TAXI.
2. The solution detects that the mobile is moving past the last lit segment of activated TCL and triggers a the Alert that is displayed on the concerned Tower Ground Controller's/Apron Manager's HMI.
3. The Tower Ground Controller/Apron Manager verifies the situation, takes all necessary actions, delivers further taxi instructions via R/T and update the TAXI route on the HMI.
4. The Flight Crew continues to taxi the aircraft according to the updated TAXI clearance received.
5. The solution verifies that the aircraft is conforming with the updated TAXI route and cancels the NO TAXI/No FtG Alert.
6. The Use Case ends.

Failure Flow

1. In the case where an alert is not triggered due to a solution failure then the Tower Ground Controller/Apron Manager and Flight Crew will be relied upon to identify the potentially hazardous situation and resolve the problem as quickly and safely as possible. This is often the case today where these alerts do not exist.

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2. In the case of a false alert the Tower Ground Controller/Apron Manager will assess the situation as soon as the alert is presented, and if the alert is deemed to be false, cancel the alert and inform the supervisor of the error.

3.3.3 Differences between new and previous Operating Methods

Activities (in EATMA) that are impacted by the SESAR Solution	Current Operating Method	New Operating Method
Check Planned Taxi-in/out Route Calculated by the System	ATCO need to check that the route calculated by the system is suitable for FtG clearance, and should restrict the clearance limit to avoid conflicts.	ATCO need to check that the route calculated by the system is suitable for Full FtG clearance without any intermediate clearance limits (cleared all the way to RWY holding or parking stand).
Commence to Drive along Cleared Route	The vehicle driver expect TCL to be switched on in front of the aircraft and provide guidance all the way to the clearance limit.	When there is a conflict, the solution will discontinue to switch TCL on in front of the vehicle, instructing it to stop/move slowly to give way to another mobile.
Create and Verify Planned Route	The ATCO create a route for a vehicle to be followed by FtG.	The ATCO create a route for a vehicle to be followed by FtG with possible automatic instructions also.
Manage No Taxi/No FtG Alert	The No Taxi alert means that the aircraft has moved in violation of the taxi clearance, and the ATCO has to react to the situation, and determine further control actions.	The No Taxi alert means that the aircraft has moved in violation of the taxi clearance, or in violation of a temporarily stop instruction given by the solution in the case of No FtG alert. The ATCO has to react to the situation, and determine further control actions.
Monitor situation (FTG)	The controller monitors the situation, detect conflicting situations, and issue instructions to resolve conflicts.	The controller monitors the situation and is informed by the solution about how conflicting situations will be resolved by the solution.
Provide ATC Clearance (FTG)	The flight crew receive a single instruction to 'follow-the-greens' from air traffic control (ATC).	The flight crew receive a single instruction to 'follow-the-greens' from air traffic control (ATC), and

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		informed to stop in the cases TCLs are not being lit.
Raise No Taxi/No FtG Alert	The solution will raise a NO TAXI alert only if the aircraft violates the taxi clearance.	The solution will raise a No Taxi/No FtG alert if the aircraft violates the taxi clearance, and also if it violates an automatic instruction modifying/amending the clearance.
Taxi to/from stand following the TCL	The flight crew expect TCL to be switched on in front of the aircraft and provide guidance all the way to the clearance limit	When there is a conflict, the solution will discontinue to switch TCL on in front of the aircraft, instructing it to stop/move slowly to give way to another aircraft, or to maintain spacing to an aircraft in front.
Update Taxi Route in the ATC System	If the aircraft started taxi without clearance, made a wrong turn, or continued passed the clearance limit, the ATCO has to update the clearance to something the aircraft can perform.	In addition to making updates as described for current situation, the ATCO will have to update taxi clearance in situations where NO TAXI/No FtG was triggered by an aircraft violating an automatic system generated instruction to stop to give way to another aircraft.

Table 6: Differences between new and previous Operating Method

The Guidance assistance through AGL (SESAR solution #47/Release5 – the previous operating method) provides the automated switching of the following visual aids in conjunction with Controller inputs, providing individual guidance information to any mobile which has a cleared taxi route:

- Taxiway Centreline Lights (TCL)
- Lighted Stop Bars.

Whilst other guidance means are partly or fully depending on on-board installations, guidance via TCL is purely a ground-based service which works in conjunction with the A-SMGCS Surveillance and Routing services as well as the Electronic Controller Input (ECI).

The Full Guidance assistance to mobiles (new operating method) improves the guidance and flow of mobiles on the movement area, by automatically detecting conflicting situations and instructing mobiles, by use of AGL, to stop or slow down to resolve conflicts. The following sections describe the different means of Guidance.

3.3.3.1 Automatic Switching of the Taxiway Centreline Lights (TCL)

In [basic] Guidance assistance through airfield ground lighting, Taxiway centre line lights (TCL) are automatically and progressively switched on in segments (or individually) as the aircraft (or the vehicle) moves along its assigned route. Pilots and vehicle drivers receive a single instruction to 'follow-the-greens' from air traffic control (ATC).

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The **Full** guidance assistance through airfield ground lighting solution also detects conflicts between aircraft (or the vehicle) moving along its assigned route, and Taxiway centre line lights (TCL) will stop being progressively switched on for one of the aircraft in a conflict situation - the aircraft that is determined by the solution to give way to the other aircraft.

So, the Full Guidance Service takes into account other traffic for spacing to guide the mobile as it progresses along its assigned route and allocates priority between mobiles based on local operating rules (e.g. Runway exit versus parallel taxiways, aircraft versus vehicle, aircraft converging or crossing at intersections and taxiways passing close to push back routes or other taxiways where insufficient wingtip separation exists).

3.3.3.1.1 Presentation of TCL to Controllers

For the Controllers to remain in the loop on guidance information being provided to Flight Crews and Vehicle Drivers, the current status of the TCL for each movement in his/her area of responsibility needs to be able to be displayed on the HMI. The TCL information presented needs to be minimized to what is operationally relevant to avoid clutter on the screen.

For the Full guidance assistance through airfield ground lighting solution the Controller needs to have indication of when activation of TCLs is being restricted by the system when two or more mobiles are converging, where one of the mobiles is required to give way to the other(s). The Controller also requires an easy means of changing the priority of the TCL.

3.3.3.2 Automatic Switching of Stop Bars

In [basic] Guidance assistance through airfield ground lighting, stop bars are switched off by the Controller as the aircraft (or the vehicle) moves along its assigned and cleared route, while in **Full** guidance this is done automatically.

As the **Full** guidance assistance also detects conflicts between aircraft (or the vehicle), and Taxiway centre line lights (TCL) will stop being progressively switched on, and stop bars switched off, for one of the aircraft in a conflict situation, and involved stop bars will in such situations remain lit while the aircraft (or the vehicle) is instructed to not progress.

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4 Safety, Performance and Interoperability Requirements (SPR-INTEROP)

4.1 General Guidance requirements

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0010
Title	TCL activation on clearances
Requirement	The Taxiway Centreline Lights shall be switched on in front of a mobile to configurable distances, after an electronic taxi, Line Up, Cross, Enter, Tow or Proceed Clearance input have been performed
Status	<validated>
Rationale	When the Tower Ground or Runway Controller instructs a mobile to move along a given route, the corresponding lamps must be activated in front of this mobile. The distance for a taxi clearance may be different than for a line up, a cross, or tow, or proceed. A taxi clearance will lit TCLs to the distance used. A Line up clearance should lit all TCL onto the runway regardless of the distance, and a cross clearance should lit all the TCL in the crossing segment
Category	<Operational>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0020
Title	TCL activation on conditional clearance
Requirement	The Taxiway Centreline Lights should be switched on in front of a mobile to configurable distances following the input of a Conditional Line Up Clearance via the ECI when the condition associated to the Clearance is satisfied.
Status	<in progress>
Rationale	When the Tower Runway or Ground Controller instructs a Conditional Clearance, the TCL should be lit in front of the mobile according to the cleared route once the condition is satisfied. (requirement created within the OSED Part II - SAR framework)
Category	<Operational>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0030
Title	Automatic switching on of TCL for landing aircraft
Requirement	The Taxiway Centreline Lights should be switched on for all the available runway exits (uni-directional from the runway towards the taxiway) up to a point what is defined as the clearance limit of a landing clearance, when an arriving aircraft is T seconds or D nautical miles from the runway threshold.
Status	<validated>

Rationale	This requirement would be applicable in the case where the TCL of the available runway exits are not permanently lit. This will guide the aircraft to stop and wait at the correct clearance limit and wait for the taxi clearance in situation where a taxi clearance cannot be given when vacating the runway. The appropriate point where the aircraft is actually clear of the runway such that other aircraft can land or take off.
Category	<Operational>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0040
Title	TCL indication on A-SMGCS
Requirement	The Tower Controller shall be provided with the information on lit Taxiway Centreline Lights on the solution HMI
Status	<validated>
Rationale	The Tower Controller need a detailed status of the individual TCL.
Category	<Safety> , <Human Performance> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Monitor situation (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment

		[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0060
Title	Solution deactivation
Requirement	The Tower Controller shall be able to activate and deactivate the Full Guidance Assistance to mobiles solution
Status	<validated>
Rationale	This requirement covers the situation where there is a need to override the solution due to a failure or whatever.
Category	<Operational> , <Human Performance> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0180
Title	Progressive switching on TCL along mobile's route
Requirement	The Taxiway Centreline Lights shall progressively be switched on in sequence in front of the mobile in order to guide the movement of a mobile along its cleared route based on the mobile's current position.
Status	<validated>
Rationale	The Guidance service needs to progressively switch on a number of lamps or segments of lamps ahead of the mobile, then switch them off behind it.

Category	<Safety> , <Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0181
Title	Progressive switching off TCL along mobile's route
Requirement	The Taxiway Centreline Light shall be switched off behind the mobile as it progresses along its route.
Status	<validated>
Rationale	The Guidance service needs to progressively switch on a number of lamps or segments of lamps ahead of the mobile, then switch them off behind it.
Category	<Safety> , <Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0190
Title	Spacing rules
Requirement	Spacing rules shall take into account if routes are merging or in-line, the types of aircraft, the weather conditions, and other conditions requiring different spacing.
Status	<validated>
Rationale	The solution controls the movement of mobiles by switching the AGL on/off, taking into account spacing rules. Due to different types of aircraft, the presence of vehicles, the weather conditions, the day time, local and other restrictions the visualized spacing can change. This includes applying the spacing between the lit TCL of two mobiles in trail on the same route.
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0280
Title	TCL switching off in case of route deviation
Requirement	If the solution detects a route deviation the TCL shall be switched off.
Status	<validated>
Rationale	In case of route deviation, there should be no visual guidance indications until the ATCO has resolved the issue through a new clearance.
Category	<Operational> , <Safety> , <Human Performance>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Manage No Taxi/No FtG Alert
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [CMAC-03] No Taxi / No FtG Alert

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0290
Title	CMAC – Taxi Conformance Alert
Requirement	The Tower Controller shall receive an Alert when an aircraft is moving on a taxiway without having received a TAXI instruction. This includes when it is being guided by a means such as activated TCL (Follow the Greens) and it overruns the activated TCL.
Status	<validated>
Rationale	The Controller needs to know when aircraft are moving without authorisation
Category	<Operational>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Raise No Taxi/No FtG Alert
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [CMAC-03] No Taxi / No FtG Alert

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0330
Title	Status of the Guidance service
Requirement	The Tower Controller shall be informed about the status of the solution and be alerted in case of a failure.
Status	<validated>

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Rationale	Tower Controllers shall be aware of the status of the A-SMGCS Guidance service at every moment.
Category	<Operational> , <Safety> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Check Planned Taxi-in/out Route Calculated by the System
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0340
Title	Reception of indication that LVPs are in force
Requirement	The solution shall receive information whether LVPs are in force.
Status	<validated>
Rationale	When LVPs are in use, guidance spacing is different.
Category	<Safety> , <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0410

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Title	LVP separation in use
Requirement	The Tower Controller shall be informed of when LVP operation is in force and LVP spacing values are in use for guidance.
Status	<validated>
Rationale	It is important that the ATCO is aware if the system is considering the LVP separation once those procedures are applicable. (requirement created within Part IV - HPAR framework)
Category	<Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0390
Title	Clearances inputted on the HMI
Requirement	The Tower Controller shall be able to see the clearances/instructions on the HMI inputted into the system.
Status	<validated>
Rationale	To increase awareness of the current situation and instructions given. (requirement created within Part II - SAR framework)
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier

<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [CMAC-03] No Taxi / No FtG Alert

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0420
Title	Pilots not able to see TCL
Requirement	Operating methods shall be defined in case of pilots are not able to see the TCL.
Status	<in progress>
Rationale	To cover all the situations that could occur during operation. (requirement created within Part II - SAR framework)
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

4.2 Requirements for conflicts, prioritisation and control of mobiles

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0090
Title	Priority rules
Requirement	Priority of mobiles in conflict situations shall be based on rules, and use data such as distance from intersection, departure/arrival, TTOT, or order of electronic flight strips.
Status	<validated>

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Rationale	The aim of the Guidance Service is to take into account other traffic for spacing and guide mobiles as they progress along their assigned routes and allocates priority between mobiles based on local operating rules
Category	<Operational> , <Safety> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0110
Title	Automatically resolving conflicting situations
Requirement	The Taxiway Centreline Lights shall discontinue to be switched on in front of the appropriate mobile(s) on the taxiway when a conflicting converging situations have been detected to achieve adequate spacing between the mobiles., and give the priority to the other mobile
Status	<validated>
Rationale	The solution (or Tower Controller decisions) regarding priorities in conflicting situations, have to be conveyed to the involved Flight Crews and Vehicle Drivers.
Category	<Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Monitor situation (FTG)

<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02-W2-21.4-SPRINTEROP-AL01.0400
Title	Indication of conflicting routing and priority
Requirement	When the solution detects a conflicting situation, the Controller shall be provided with information that a conflict is detected, who has priority, and where the predicted conflict is, preferably without having to make input to the system.
Status	<validated>
Rationale	The ATCO needs to be informed of the system's prediction and resolution. The indication could be linked to the display of the routing, indicating where the route conflict will occur, and the prioritization given by the system. This will be ahead of when TCLs are being restricted, and this is when the ATCO have the opportunity to swap priorities. (requirement created in coordination between Part II – SAR and Part IV – HPAR)
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Monitor situation (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0140

Title	Indication of conflict resolution
Requirement	When a mobile's TCLs are being restricted in order to prioritise converging mobiles at intersections or to avoid a deadlock situation, the Controller shall be provided with information indicating the last lit TCL.
Status	<validated>
Rationale	The ATCO needs to be informed of the system's restrictions on guidance by TCL. The indication could be a red mark or line at the end of the TCL indication.
Category	<Human Performance> , <Safety> , <Operational>

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0141
Title	Late swap of priority or late re-routing
Requirement	When a mobile's TCLs are being restricted in order to prioritise converging mobiles at intersections or to avoid a deadlock situation, the Controller shall not swap priority or re-route the mobile without coordinating the taxi instruction by R/T with the flight crew/driver
Status	<validated>
Rationale	A flight crew/driver is already instructed by FtG guidance to give way/stop or to proceed. A late and sudden change in the instructed FtG guidance (changing the guided route, a sudden decrease in the TCLs guiding the mobile, or a sudden increase in the TCLs guiding the mobile) would confuse flight crew/driver, and may create a situation where it is not possible to follow the FtG guidance (making a turn, or stopping at an intersection).
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Monitor situation (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment

		[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0150
Title	Overriding of solutions to conflicting situations
Requirement	The Tower controller shall be allowed to swap the priority between converging mobiles or mobiles in a predicted deadlock situation.
Status	<validated>
Rationale	The ATCO needs to be able to change the system's resolution in case it does not match his/her intent
Category	<Safety> , <Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

4.3 Requirements for Stop Bar control

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0050
Title	Stop bar activation by the Controller
Requirement	The Tower Controller shall be able to switch on/off any stop bar individually.
Status	<in progress>

Rationale	Ultimately, the Controller should remain responsible for the activation or de-activation of stop bars and can override the system's decisions.
Category	<Safety> , <Human Performance> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Monitor situation (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0210
Title	Automatic switching of stop bars
Requirement	Taxiway and apron stop bars shall be switched on or off to control the movement of a mobile along its cleared route.
Status	<in progress>
Rationale	Stop bars need to be switched on/off in support of the full guidance and the TCL.
Category	<Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0220
Title	Stop bar de-activation following a Tower Controller Take-Off input
Requirement	The runway stop bar in front of an aircraft shall switch off following the input of a Take Off Clearance by a Tower Controller via the Electronic Clearance Input, when no previous line-up Clearance has been input.
Status	<validated>
Rationale	Stop bar switched off based on Tower Controller Take-Off input without previous line-up clearance, eliminating the need for separate line-up clearance.
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0230
Title	Stop bar de-activation following a Tower Controller Line-Up, Cross or Enter input
Requirement	The runway stop bar in front of an aircraft shall switch off following the input by a Tower Controller of a Line Up, Cross or Enter Clearance via the Electronic Clearance Input.
Status	<validated>
Rationale	Stop bar regulation associated to Tower Controller Line-Up, Cross or Enter input.
Category	<Human Performance> , <Safety> , <Operational>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0240
Title	Automatic stop bar re-activation
Requirement	A stop bar shall automatically switch on when one or more mobile(s) have passed over it by D metres or T seconds.
Status	<validated>
Rationale	In order to be an active stop bar for other mobiles
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0250
Title	Automatic switching off of TCL beyond stop bar
Requirement	When a Stop Bar is active, any TCL installed beyond the stop bar shall be extinguished for a distance of at least 90 m.
Status	<validated>

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Rationale	Consistency in guiding information between stop bar and TCL
Category	<Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-02] Guidance of vehicles - AGL environment [NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0260
Title	Prevent wrong stop bar guidance
Requirement	A stop bar shall not be switched off if there is another uncleared mobile is between the cleared mobile and the runway stop bar
Status	<validated>
Rationale	It should be assured that no mobile get incorrect guidance to cross a stop bar
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0270
Title	Automatic switching off of stop bar on Conditional Line-Up clearance
Requirement	The runway stop bar in front of an aircraft should switch off following the input of a Conditional Line Up Clearance via the ECI when the condition associated to the Clearance is satisfied.
Status	<in progress>
Rationale	When the Tower Runway Controller provides a conditional line-up to an aircraft, the runway stop bar in front of it should be automatically de-activated.
Category	<Safety> , <Operational> , <Human Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Provide ATC Clearance (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0310
Title	Stop Bar indication
Requirement	The Stop bar status (on/off) shall be provided to the Tower Controller on the A-SMGCS HMI
Status	<validated>
Rationale	The Tower Controller should have the ability to get a detailed status of the Stop Bars.
Category	<Human Performance> , <Safety> , <Operational>

[REQ Trace]

Relationship	Linked Element Type	Identifier

<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<Activity>	Monitor situation (FTG)
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-AL01.0380
Title	Stop bar de-activation following a Tower Controller Taxi input
Requirement	The taxiway or apron stop bar in front of an aircraft shall switch off following the input of a Taxi clearance by the Tower Controller via the Electronic Clearance Input.
Status	<in progress>
Rationale	Stop bar regulation associated to Tower Controller Taxi input. (requirement created within Part II - SAR framework)
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

4.4 Requirements for training and procedures

The following set of requirements has been produced as part of the Safety Requirements at Design level (SRD) within SPR-INTEROP/OSED Part II – Safety Assessment Report.

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-SAFE.0001

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Title	Contingency procedures for system failure
Requirement	Contingency procedures shall be in place in case the solution fails to provide guidance to aircraft and vehicle movements (through visual aids on the airport surface).
Status	<in progress>
Rationale	Safety Requirement at Design level derived from SPR-INTEROP/OSED Part II – SAR activities.
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-SAFE.0002
Title	Contingency procedures for FtG failure
Requirement	ATCO training shall include contingency procedures in case of FtG failure.
Status	<in progress>
Rationale	Safety Requirement at Design level derived from SPR-INTEROP/OSED Part II – SAR activities.
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL)

		[NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-SAFE.0003
Title	Contingency procedures for FtG malfunction
Requirement	ATCO training shall include contingency procedures in case of FtG malfunction.
Status	<in progress>
Rationale	Safety Requirement at Design level derived from SPR-INTEROP/OSED Part II – SAR activities.
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-SAFE.0004
Title	Runway entry and crossing operating method (ATCO)
Requirement	ATCO training shall include operating method for runway entry and crossing.
Status	<in progress>
Rationale	Safety Requirement at Design level derived from SPR-INTEROP/OSED Part II – SAR activities.
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-SAFE.0005
Title	Runway entry and crossing operating method (pilot/driver)
Requirement	Vehicle driver and pilot training shall include operating method for runway entry and crossing.
Status	<in progress>
Rationale	Safety Requirement at Design level derived from SPR-INTEROP/OSED Part II – SAR activities.
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

[REQ]

Identifier	REQ-02.W2.21.4-SPRINTEROP-SAFE.0006
Title	Capacity reduction
Requirement	ATCO shall be able to prevent overload and manage workload by reducing capacity.
Status	<in progress>

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Rationale	Safety Requirement at Design level derived from SPR-INTEROP/OSED Part II – SAR activities.
Category	<Operational> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.02-W2-21.4
<ALLOCATED_TO>	<ActivityView>	[NOV-5] [GUID-01] Plan and provide Taxi-in/out Routing for an inbound/outbound flight (AGL) [NOV-5] [GUID-02] Guidance of vehicles - AGL environment

5 References and Applicable Documents

5.1 Applicable Documents

Content Integration

[1] PJ19 D5.11 EATMA Guidance Material and Report (2019), 28/10/2019

[2] EATMA Community Wiki https://ost.eurocontrol.int/sites/eatmac

[3] SESAR ATM Lexicon

Content Development

[4] D2.5: SESAR 2020 Concept of Operations (edition 01.00.00) [29/10/2020]

[5] W2 High Level Operational Requirements, 03/07/2020

System and Service Development

[6] SESAR 2020 Requirements and Validation Guidelines Wave 2 (edition 00.02.01) [29/10/2020]

Performance Management

[7] D4.7: PJ19.04: Performance Framework (2019) (edition 01.00.01) [29/10/2020]

[8] PJ19-W2 D4.0.1 Validation Targets - Wave 2, 04/05/2021

[9] Guidelines for Producing Benefit and Impact Mechanisms, 09/01/2020

[10]D4.0.30 S2020 Common Assumptions (edition 01.00.00)

[11]D110: C.02-D110 Updated D02 after MP Campaign (edition 00.01.01)

Validation

[12] EOCVM V3 Volume 1 (1.0) & Volume 2 (1.0), 17/04/2020

System Engineering

[13]System Engineering - Methodology for the V&VP, V&VI and Demonstration Platform development, 18/02/2020

Safety

[14]D4.0.060: SESAR Safety Reference Material (edition 00.04.01)

[15]D4.0.050: Guidance to Apply SESAR Safety Reference Material (edition 00.03.01)

[16] D04: Resilience Engineering Guidance Final Deliverable (edition 00.00.12)

Human Performance

[17]SESAR Human Performance Guidance Reference Material, 27/08/2020

[18]16.006.05 D27 SESAR Human Performance Assessment Process V1 to V3 – including VLDs

[19] D4.0.070: SESAR Human Performance Assessment Process V1 to V3 – including VLD (edition 00.03.01)

Environment Assessment

[20]ENV - Guidance Reference Material, 20/12/2019

[21]D4.0.080 SESAR Environment Assessment Process (edition 04.00.00)

5.2 Reference Documents

[22]ED-228A SAFETY AND PERFORMANCE REQUIREMENTS STANDARD FOR BASELINE 2 ATS DATA COMMUNICATIONS (BASELINE 2 SPR STANDARDS).

[23]EUROCONTROL A-SMGCS Specification No171 V2.0

[24]D2.010 - SESAR Solution PJ03a-01 SPR-INTEROP/OSED for V2 (integrated surface management)

[25]D6.4.003 - PJ.02-W2-21.4 VALR

[26]ICAO Doc. 9432 Manual of Radiotelephony

[27]SESAR SOLUTIONS CATALOGUE 2019 Third edition ISBN 978-92-9216-108-8 Release 5 SESAR Solution #47 “Guidance assistance through airfield ground lighting”

[28]SESAR P06.07.01 D32, Final OSED for Conflicting ATC Clearances and Conformance Monitoring Alerts for Controllers, ed. 01.00.00, 06 September 2016

[29]SESAR P06.07.02 D46, OFA04.02.01 (Integrated Surface Management) Final OSED, ed. 00.01.02, 10 November 2016

[30]ICAO Advanced Surface Movement Control and Guidance Systems (A-SMGCS) Manual, Dos 9830 AN/452, First Edition 2004.

Appendix A Cost and Benefit Mechanisms

A.1 Stakeholders identification and Expectations

Stakeholder	Involvement	Why it matters to stakeholder
Airspace Users	Main involvement is participation on workshops and meetings.	The provision of an enhanced guidance assistance is expected to increase pilots' situational awareness resulting with a positive impact on safety.
ANSP	Contribution to the definition of the operational concept and to preparation and execution of the concerned validation activities.	Increased controllers' situational awareness resulting from a more efficient integration of information coming from different functionalities (such as routing, planning and guidance).
Vehicle driver	Main involvement envisaged regard their participation in the execution of planned validation activities.	Increased vehicle drivers' situational awareness resulting from the on-board display of guidance information (including airport layout, dynamic traffic context information, aircraft's own position, taxi route issued by ATC)

Table 7: Stakeholder's expectations

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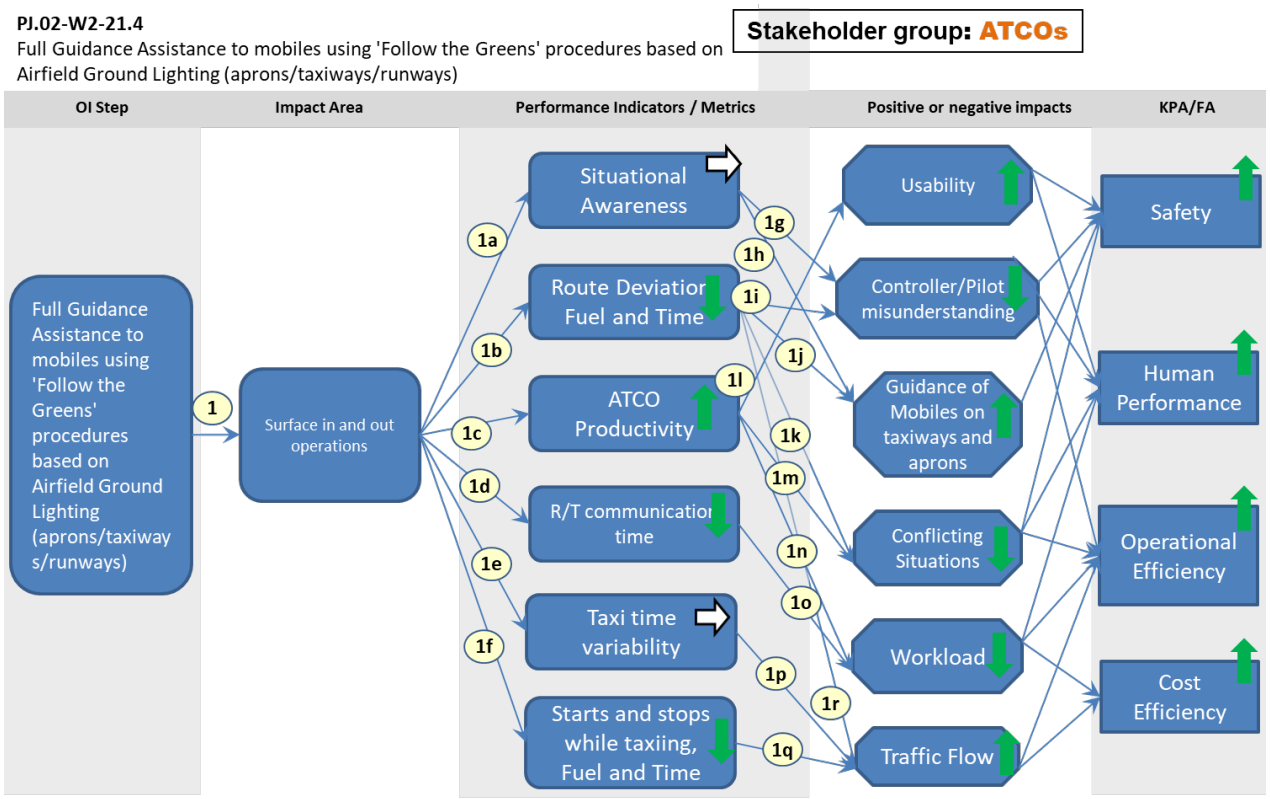
A.2 Benefits mechanisms



N°	Mechanism descriptions
	Full Guidance Assistance to mobiles using "Follow-the-Greens" procedures Using Airfield Ground Lighting, mobiles will be guided along their cleared route
1	**Taxi in and Taxi out operations** Taxi in and Taxi out operations are expected to be impacted by the definition of Full Guidance Assistance to mobiles using "Follow-the-Greens" procedures
1a	**Situational Awareness** The higher level of automation is expected. The task of conflict detection and resolution is somewhat shifted to the machine which may lead to reduced situational awareness, especially in dense traffic situations. However, ATCO would be able to modify the route if the conflicting situation could be solved more efficiently. His/her active involvement would be essential to stay in the loop. Note that the stakeholders in this BIM are the ATCOs- the flight crew SA is expected to increase.
1b	**Route deviations, Fuel and Time** The precise guidance of the follow the greens concept will ensure that mobiles adhere to the route that ATCOs has assigned leading to less route deviations, optimised fuel consumption and taxi time

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1c	**ATCO Productivity** The solution is expected to support the ATCO's efficiency as it will take on the conflict detection and resolution tasks by automatically switching the TCL and Stop bars. It is expected that the number of managed aircraft by one ATCO will be higher thus it will have a positive impact on the ATCO productivity.
1d	**R/T communication time** Availability of automated switching of AGL and the related "Follow-The-Greens" procedures is expected to result in less R/T communication time when giving taxi instructions. This supports the ATCO in being efficient, thus has an indirect link to Cost Efficiency KPA.
1e	**Taxi time variability** Availability of AGL may have an impact on taxi time variability, however, the exact direction of the change is not yet established.
1f	**Starts and Stops while taxiing, Fuel and Time** Availability of AGL may result in less stops and starts while taxiing, if the ATCO is sufficiently engaged in finding more optimal taxi routes, optimised fuel consumption and taxi time.
1l	**Usability** The system functionalities and the HMI has the potential to support ATCO's work as the system will take on the conflict detection and resolution tasks by automatically switching the TCL and Stop bars. Reduction in workload is hypothesized, however, only when trust in the system is established. Safety nets like CMAC and CATC can help ATCO's in the management of the traffic. However, intuitive route editing functionality is imperative, and also a correct sequencing logic should be included in the system. Those impacts are related to Safety (SAF) and Human Performance (HP) KPA.
1g 1i	**Controller / Pilot misunderstanding** The expected increase of situation awareness of the flight crew, as well as the reduction of route deviation occurrences, are linked to a reduction of ATCO / pilot misunderstanding. The described impacts are linked to the Safety (SAF) and Human Performance (HP) KPA and also on Operational Efficiency.
1h 1j	**Guidance of Mobiles on taxiways and aprons** Automated switching of TCL and stop bars will guide mobiles more efficiently and expeditiously on the airport surface. The AGL is only switched on in front of mobiles that are moving instead of on all equipped taxiways regardless of traffic movements. The improved guidance is expected to have a positive impact on both Safety (SAF) and Human Performance (HP) KPAs
1k 1m	**Conflicting situations** The automated switching of AGL will de-conflict converging and opposing traffic. This expects to have an impact on both Safety (SAF) and Human Performance (HP) KPAs and also on Operational Efficiency.

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1n 1o	**Workload** The reduction of R/T communication time, and the increased ATCO productivity will have a direct impact on workload, which is linked to Human Performance (HP). The decrease of the workload has also a link to Operational and Cost Efficiency (i.e., the number of flights to be handled/hour may increase due to the workload and R/T reduction). Obviously the new technology tested by the Solution has a real impressive added value to help and to increase the improvement in traffic management by the ATCOs on duty, during unusual weather situation with reduced capacity on the airfield, and so it allows the direct improvement in ATCO productivity due to additional number of aircraft handled within the same operational scenario, when compared with the Reference. Reduction in workload is hypothesized, however, only when trust in the system is established, even if it has been validated by multiple SESAR Solutions and validation Exes tested on different ECAC Airports
1p 1r	**Traffic flow** Reduction in the frequency of stops and starts while taxiing and route deviation should result in a more efficient and smoother traffic flow. This would be further supported if the solution was to positively impact taxi variability, and in traffic management by the ATCOs. Overall, the optimised traffic flow would have an impact on Operational Efficiency KPA and on Cost Efficiency KPA (i.e. with smooth traffic flow the ATCO may take on more flights /hour.)

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